APPETITIVE SEARCH BEHAVIORS AND

STEREOTYPIES IN CAPTIVE ANIMALS

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DEDICATION

This thesis is dedicated to my father, Juan J. Fernandez, M.D., whose encouragement, as

well his own career ambitions, inspired me to enthusiastically pursue my academic goals.

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Eduardo J. Fernandez

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Behavioral stereotypies in captive animals have been defined as repetitive, largely invariant patterns of behavior that serve no obvious goal or function (Mason, 1991a; Ödberg, 1978). Stereotypies are commonly attributed to boredom or fear, and are typically "treated" by enriching captivity with distracting, appealing stimuli. These stimuli often include food presented at times other than regular feedings, and as a result, engage species-typical foraging behaviors that reduce stereotypies.

This thesis applies a "foraging loop" hypothesis to the behaviors of contrasting species of marine mammal carnivores, polar bears and walruses. Polar bears in the wild commonly spend the majority of each day traveling to locate prey; captive polar bears commonly spend several hours a day in locomotor stereotypies preceding their scheduled daily feeding time. Experiments 1-4 presented small samples of food and scents on several schedules, examining their effects prior to, during, and after the schedule. Most schedules reduced stereotypies and increased general activity prior to and during the schedule.

In contrast to the lengthy locomotor search of wild polar bears, walruses in the wild spend more time "grazing" in beds of mollusks on the ocean floor, using their flippers, vibrissae, and mouths to locate and suction out mollusks. Captive walruses spend the majority of their day circle swimming, and mouthing and sucking inedible objects in their enclosure. Experiments 5-6 found that introducing mats with food or

"boomer balls" with food increased contact and activity and decreased stereotypic circle swimming and sucking relative to controls.

These data support three conclusions: (1) individual stereotypies appear based on incomplete, repeating loops of foraging behavior; (2) providing stimuli supporting a more complete sequence of search behaviors reduces stereotypies and increases non-stereotypic activity; and (3) a descriptive, analytic approach based on how foraging behaviors relate to the captive feeding procedures can facilitate understanding of stereotypies and suggest methods to reduce them.

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Appetitive Search Behaviors and

Stereotypies in Captive Animals

Stereotypic behaviors (referred to here as stereotypies or stereotypic activity) in captive animals have been defined as voluntary movement patterns without obvious function or goal, which are: (1) performed repeatedly, and (2) relatively invariant in form (Mason, 1991a; Ödberg, 1978). A range of stereotypies have been observed in captive animals, including: regurgitation and re-ingestion of food by chimpanzees (*Pan troglodytes*) (Baker & Easley, 1996), pacing in the American black bear (*Ursus americanus*) (Carlstead, Seidensticker, & Baldwin, 1991), coprophagy in gorillas (*Gorilla gorilla gorilla*) (Stevenson, 1983), and oral stereotypies in pigs (biting, chewing, and mouthing tether chains and stall bars) (Lawrence & Terlouw, 1993).

In addition to obvious problems with stereotypies producing abrasions or tissue damage from the repetitive motions, the occurrence of stereotypies in captive animals has generally been viewed as undesirable for four related reasons. First, many researchers have argued that stereotypies express boredom and fear reactions to aversive and stressful aspects of captivity. These circumstances include unnatural and/or threatening situations and restraints, and a lack of variable and/or species appropriate stimulus input (Broom, 1986; Dawkins, 1990; see Mason, 1991b for a review). Second, direct evidence that stereotypies are markers of stress in captive animals has come from the increased cortisol levels, a frequently used measure of stress, often shown by animals exhibiting stereotypies (Pell and McGreevy, 1999). Third, indirect evidence of the undesired effects of stereotypies includes a study showing that the natural home-range size of a species was positively correlated with both frequency of stereotypies and infant mortality in captivity

(Clubb and Mason, 2003). Fourth, observers often believe that stereotypies are a negative indicator of well-being that needs to be attended to promptly (Forthman and Ogden, 1992).

There is an additional problem for carnivores with respect to stereotypies. Carnivores often exhibit stereotypies in the mid-to late afternoon, beginning several hours prior to their large daily feeding time. The timing of these stereotypies occurs at a peak viewing time for zoo visitors. Not only do the stereotypies lead visitors to question whether the animals are well cared for, they also interfere with the important educational goal of zoos to display animals engaged in behaviors characteristic of their natural environment. In short, given the negative issues surrounding the display of repetitive stereotypies, zoos are actively searching for strategies to increase "natural" behaviors, and decrease abnormal repetitive behaviors potentially related to distress.

The attribution of stereotypies to boredom and/or stress produced by a barren, uninteresting, or threatening physical environment (Barnett & Hemsworth, 1990; Hediger, 1964) has had the effect of influencing zoos to construct larger and more naturalistic exhibits, frequently occupied by multiple animals and including structures and items intended to be "enriching" (Mellen & MacPhee, 2001; Shepherdson, 1998). Some of these efforts have reduced stereotypies in particular species, with attendant increases in the breadth of an animal's expressed repertoire and an increase in the public appeal of exhibits. However, stereotypies in large carnivores are still a significant problem (Carlstead, 1996; Carlstead, 1998), taking such forms as pacing in polar bears (Wechsler, 1991), flipper sucking in walruses (Kastelein & Wiepkema, 1989), and circle swimming in both species.

Stereotypies and Their Foraging-Based Interventions

In the past few decades, many zoos and other settings with captive animals have attempted to increase stimulation available to carnivores by presenting prey-like stimuli, thereby reducing stereotypies and increasing "naturalistic" predatory behavior, while educating visitors about the species. For example, Markowitz and LaForse (1987) presented artificial moving prey to captive tigers (*Panthera tigris*) and servals (*Felis serval*) and generated species-typical hunting behaviors. Similarly, hiding multiple daily rations of food around the enclosure of captive-born leopard cats (*Felis bengalensis*) decreased pacing and increased exploration (Shepherdson, Carlstead, Mellen, and Seidensticker, 1993).

Introducing stimuli supporting foraging in omnivores and herbivores also has been successful in reducing stereotypies and/or increasing "naturalistic" foraging behavior. For example, a hamadryas baboon (*Papio hamadryas hamadryas*) troop was provided with a single manipulable small box filled with food, resulting in non-dominant troop members foraging more widely within their enclosure and with decreased aggression when compared to a big box filled with food (Jones and Pillay, 2004). Offering food hidden in manipulable objects once daily to an American black bear (*Ursus americanus*) reduced stereotypic pacing significantly when compared with feeding once daily in the den (Carlstead, Seidensticker, and Baldwin, 1991). Enrichment for two species of sea turtles in the form of manipulable items, "waterfalls" (a flowing water hose hung over the enclosure), and feeding devices, decreased resting and stereotypies while increasing random swimming and behavior focused at the (Therrien, Gaster, Cunningham-Smith, & Manire, 2007).

It is worth noting that most of the manipulations successful in reducing stereotypic activity and increasing natural behavior have focused on providing the animal with stimulus conditions that engage species-typical behaviors related to search and capture combined with small quantities of consumption. It makes sense that presenting cues related to locating and actively seeking potential prey/food (focal search behaviors) should engage the interest and attention of captive animals, thereby potentially competing with stereotypies. Further, to the extent that locomotor stereotypies in large carnivores are related to the extensive search typical of their foraging behavior in the wild, one might expect more stereotypies in large carnivores compared to other species, and a greater reduction in the stereotypies based on providing them cues that lead rapidly to more proximate search sequences and consumption.

Consider that in most zoos, large carnivores on exhibit (such as a polar bear or a large cat species) typically are fed one large meal a day at a fixed time in the late afternoon, a time often preceded by sounds and odors of food preparation and by the animal's removal from the exhibit. Large carnivores in the wild typically hunt over long times and distances to obtain infrequent, but relatively large meals. It should not be surprising that such animals engage in extensive locomotor search behavior (general search behaviors) anticipating the time of feeding by several hours (see the considerable data on active circadian anticipation of a regular daily feeding behavior in rats, a relatively small omnivore, e.g., White & Timberlake, 1998). A circardian contribution to food-search-related stereotypies also explains why one reasonably successful method for reducing stereotypic activity is to make the feeding time considerably less predictable (Bloomsmith & Lambeth, 1995).

In short, repetitious locomotion by carnivores in anticipation of one or more daily meals can be interpreted as the expression of a general search state motivated by hunger and supported and evoked by temporal and environmental cues predicting food. In this view, the expression of general search is shaped and constrained by the stimulus support (affordances) in the environment, and should persist until interrupted by cues that control focal search behaviors or eating, or until any daily temporal window for feeding is well past.

The key assumption in such a behavior systems approach to foraging (see Timberlake, 1997 for a review) is that a temporally conditioned general search state motivates expression of search behavior until the temporal window is past or the behavior is "successful" in producing access to cues eliciting and controlling the animal's transition to a more focused search state and/or consumatory behavior (Timberlake, 2001). Figure 1 shows a diagram of the hypothesized foraging sequences of carnivores in the wild and in captivity. In the wild, carnivores such as polar bears would engage in general search behaviors (such as traveling in search of prey) until they encounter sensory stimuli relevant to prey, such as the scent of a seal or identification of a seal breathing hole (both focal stimuli). They would then engage in focal search behaviors relevant to capturing the prey (such as, waiting by a seal hole or stalking prey) until the prey is captured and consumed or stored. In captivity, however, few or none of the focal stimuli that typically lead to discovering, killing, and consuming potential food would be available. Therefore, a polar bear in captivity would continue to engage in general search behaviors, such as repetitive walking bouts, until food was found and consumed.

The interpretation of stereotypies in captive carnivores as a repeated loop of search behaviors appropriate to a foraging system (i.e., the "foraging loop hypothesis") is compatible with an increased intensity of search stereotypies beginning several hours before feeding time based on circadian anticipation of the daily feeding. The animal continues to search because food is not there. Such a view of carnivore stereotypies is also compatible with evidence that stereotypies can be disrupted by providing stimuli that engage focal search and handling behaviors. For example, the procedure of hiding multiple daily rations of food around the captive enclosure produced a decrease in stereotypic activity and increase in active search behaviors in African leopards (Shepherdson, Carlstead, Mellen, & Seidensticker, 1993).

The purpose of the present research was to analyze and test a foraging systems approach to the expression of stereotypic activity of captive members of two species of large carnivores, polar bears (*Ursus maritimus*), and walruses (*Odobenus rosmarus*). The primary manipulation used was to present small amounts of food in a way that increased focal search behavior and consumption on the part of the walruses and polar bears, thus, potentially interrupting stereotyped search behaviors, such as pacing and swimming in the polar bear, and stereotyped circle swimming and flipper sucking in the walrus. The contrast between polar bears (Experiments 1-4) and walruses (Experiments 5-6) should be of interest, given that polar bears typically focus on hunting one large prey animal across a day (or multiple days) of foraging, while walruses consume many small prey items from beds of mollusks on the ocean floor during multiple feeding bouts that appear to share elements with the grazing patterns of herbivores. Therefore, I would expect

walrus stereotypies to be prominent during multiple foraging bouts during the day, rather than increasing across the day in anticipation of a single large meal.

For both polar bears and walruses, I will first characterize natural foraging behavior and point out apparent divisions between general and focal search behaviors. Then I will describe the stereotypies typically shown by these animals in the Indianapolis zoo, and for that species in other captive settings. Because polar bears are exceptionally wide-ranging carnivores, they would be expected to show more continuous locomotor search behavior typical of a general search foraging loop. Therefore, stereotypies should show large amounts of back and forth pacing or swimming, probably similar to the considerable amount of time they spend searching for seals in the wild.

In contrast, walruses are atypical large carnivores with their extensive daily foraging in beds of bivalves found on the ocean floor. In fact, much of their behavior appears only slightly different from ungulate grazers, as the walruses move along the ocean bottom, using their flippers, jets of water, and vibrissae contact to discover the shellfish followed by suctioning them free of their shells as they ingest them. Based on these reports, I expect walrus stereotypies to be composed primarily of repeated focal search and handling behaviors unsuccessful in ingesting the animals, in contrast to polar bear locomotor stereotypies based on unsuccessful location of prey in the presence of temporal and perhaps odor cues predicting their availability.

After establishing reliable categories of stereotypic activity in each species, I will examine the effects of manipulating the form, pattern, and predictability of food delivery on the stereotypic activity of each species. I expected that more frequent delivery of small amounts of food to polar bears will provide greater disruptions of their locomotor

stereotypies, than providing a large amount of food in of food in one delivery, or simply providing the scent of food without allowing consumption to complete the foraging sequence. Similarly, in the walruses I expected foraging devices that allow greater contact and direct manipulation to produce large reductions in the search stereotypies, with the form of the stereotypies a walrus typically displayed (flipper sucking or circle swimming) predicting the types of food delivery systems that would be most effective for that walrus.

CHAPTER 1: POLAR BEARS

In the wild, Polar bears (*Ursus maritimus*) are known to search widely for signs of prey (mostly seals), roaming widely over a large home range of sea ice (sometimes exceeding 518,000 km^2), testing the air for long-distance scents and eyeing distant movement (Hemstock, 1999). Polar bears travel widely across sea ice as they hunt for signs of prey (and during the appropriate season for signs of mates) (Derocher, Lunn, & Stirling, 2004). To maintain contact with their seal prey under the ice, polar bears travel large northerly and southerly distances as the ice expands and retreats (Amstrup, Durner, Stirling, Lunn, & Messier 2000). As a result, polar bears spend a considerable amount of their time in the water, and have been observed to hunt in the ocean, as well as being seen several hundred kilometers offshore (Stirling, 1988).

Ringed seals make up the majority of their diet, and they can detect young ringed seals (presumably through their excellent olfactory capabilities) hidden in snow caves 1 meter under the snow and approximately 1.6 km away (Rosing, 1996). When a bear discovers signs pointing to the presence of a seal, it switches to focused hunting behaviors (focal search), such as sitting or lying quietly in wait for seals to surface at

breathing holes, or collapsing seal lairs trying to extract their residents (U. S. Fish &

Wildlife Service, 2006). This action of sitting or lying quietly near a seal hole is known

as "still-hunting", and makes up the majority of a polar bear's focal hunting behavior

throughout the year (Stirling, 1988).

In captivity, polar bears (*Ursus maritimus*) are so well-known for stereotypies that

the Dutch language includes the verb *ijsberen* ("to polar bear"), which translates to

walking back and forth restlessly (Wechsler, 1991). Carlstead & Seidensticker (1991)

suggest that bears in general may be an extreme example of an animal "hardwired" to

forage widely because energy needs are substantial and food availability is seasonal and

variable. Carlstead & Seidensticker also suggest that the natural needs of many species of

bears to forage are not met because they are presented food in large, concentrated

portions delivered at a predictable time and place (typically when they come off exhibit at

around the same time each day), which they consume in a very short time. In addition,

this method of feeding most bear species provides few of the cues associated with

hunting for food in the wild. Carlstead and Seidensticker suggest alternate methods for

feeding bears in general, such as hiding food amongst browse in an exhibit at various

times throughout the day, which should increase the time spent searching for food by a

bear, and thus alleviate "boredom". They emphasize the need for bears to search for

hidden treats, rather than focusing on the relation of stereotypies to the bears' normal

feeding time.

In the wild, it appears that polar bears have been selected for the extensive

expression of general search behaviors in the form of traveling while visually searching

for seals and sniffing for odors over a wide area around the sea ice, behaviors designed to

collect more olfactory and visual cues. Visual or olfactory cues from potential prey should produce more directed exploration, including waiting near seal holes and stalking visible prey, specific search behaviors adapted to capture and kill.

However, in captivity few of the stimuli that elicit focal search, such as visual or olfactory prey cues, are presented. Focal search stimuli, such as food scents that result in consumable items, are usually limited to times immediately preceding a temporally predictable and instantly consumable diet. As a result, it can be argued that polar bears in captivity spend much of an almost obligatory daily foraging time stuck in a general search state produced largely (though perhaps not exclusively maintained) by circadian cues related to a fixed daily feeding time. From this viewpoint, repeated locomotor stereotypies resemble an unsuccessful foraging loop in which general locomotor search is unsuccessful in turning up any sign of prey. Given their most reliable cue for feeding in captivity is time of day, polar bears would be expected to increase foraging leading up to this predictable feed, and then diminish or stop locomotor behavior following consumption of food.

The present study examined the effects of delivering very small food items (~38.0 g whole fish each, with each fish equating approximately .25 - .5 % of a bear's diet) or food scents on fixed- and Variable-Time schedules. It was expected that these stimuli, while serving as a small fraction (or in the case of scents, none at all) of the daily amount of food consumed for an individual polar bear should serve to disrupt stereotypic general search activity by allowing the polar bears to make a transition to focal search behaviors. The scents, however, while providing stimuli related to food, may eventually produce increases in stereotyped general search behavior simply because they do not allow the

discovery and consumption of food. To clarify the effects of these conditions on the polar

bear's behavior, we took data before, during, and after the delivery of food or scents,

depending on the type of schedule and item delivered.

<div align="center">Experiment 1</div>

In Experiment 1, food items in the form of whole capelin (a small fish,

approximately 38 g each) were delivered to polar bears on several Fixed-Time (FT; see

Methods procedures section for description) schedules ranging from 1 to 10 min,

preceded and followed by baseline observations. Small food items were delivered on

these schedules because they provided immediately consumable objects that could be

delivered readily and frequently, thus allowing potential search patterns to move beyond

the hypothesized general search pacing and repetitive swim patterns to focal search and

consumption, without interfering with the bear's appetite during the later main feeding

times. I expected to disrupt the stereotypic locomotion of bears in the presence of food,

and, to an extent, in the period just prior to the delivery of food as the bears learned to

predict the time between deliveries of consumable snacks. I did not expect a similar

disruption of stereotypic locomotion in the period after food deliveries because this

period occurred shortly before their large daily feeding at the end of the day.

In addition, I expected more dense schedules of food deliveries (e. g., FT 1 min,

as opposed to FT 5 or FT 10 min schedules) to provide the greatest reduction in

stereotypic activity, while producing more focal search behaviors, such as standing or

rearing (frequent prey-capture assessment behaviors in polar bears in the wild). I

expected the short interfood intervals to produce the greatest increases in non-stereotypic

activity relative to the longer food intervals, but I also expected them to limit traveling

around the enclosure (relative to the longer food intervals), measured by the extent of time spent in the other enclosure areas we sampled (see methods and Entropy description below). In contrast the longer food delivery intervals (e.g., FT 5 and FT 10 min), though also producing a decrease in locomotor stereotypies relative to baseline, might also be expected to increase the bear's total use of the enclosure because they did not provide sufficient density of food to decrease searching throughout their exhibit.

Methods

Subjects and Enclosures

Two captive-born polar bears (*Ursus maritimus*) at the Indianapolis Zoo were observed in this study. Tundra, a 16-year-old female at the start of the study, was born on 11/15/1986 at the San Diego Zoo and arrived at the Indianapolis Zoo on 5/10/1988. She weighed approximately 341 kg. Pasha, a 17-year-old male at the start of the study, was born on 11/29/1985 at the Roger Williams Park Zoo and arrived at the Indianapolis Zoo on 5/20/1988. He weighed approximately 500 kg. Both polar bears shared the exhibit diagramed in Figure 1 containing an area for swimming as well a larger land area. The land area was 212 m^2 and consisted of relatively flat pathways as well as several artificial cliffs and boulders. The pool area was connected to the land area and was 80 m^2.

When not on exhibit, the bears were placed in one of four night enclosures, each approximately 37 m^2. During the winter season, polar bears were on exhibit from 0900 to 1600 hr, and during summer hours, from 0900 to 1700 hr. The majority of their food was given in their night enclosures when the bears came off exhibit. Some food from their daily diets was also aperiodically given throughout the day as enrichment, and was delivered both on and off exhibit (between 1600 or 1700 and 0900 hr). Their diet

consisted of Natural Balance$^{\text{TM}}$ horse meat, capelin, herring, and various fruits and vegetables. The make-up of the diet and size of the daily portions varied throughout the year, with increases in diet leading up to the winter and decreases following it. The amount of food given seasonally was based on the zoo's nutrition plan and on the behaviors and appearance of the polar bears, such as how fast they consumed their diet, how much they weighed, and how healthy they looked.

Materials

Two video cameras were used during parts of the study, one positioned outside along a lighting fixture, and the other indoors behind a public viewing glass. The two cameras were able to record approximately 90% of the exhibit. Both cameras recorded directly to videocassette recorders (VCR's) maintained in the chemists' area of the Waters Building, and were used for training purposes and to supplement in vivo observations. Other materials included data sheets and clipboards used to record behaviors observed, Handspring Visor Neo™ PDAs (used later in the study to collect data rather than using data sheets), Timex Ironman™ repeatable countdown stopwatches, Event PC software used to collect data (developed by Dr. Jim Ha at the University of Washington for this project), laminated ethogram reference cards, a notebook, and the capelin delivered during the food schedules. The capelin were taken from the normal diet of each polar bear, and were kept in buckets (one for each bear) filled partially with ice. A lid was kept over the capelin and ice to minimize thawing and odors.

Data Collection and Procedure

Observations began in February 2003 and were conducted through February 2004. A total of 7 researchers were involved in the data collection. Data were typically

collected 3 days a week, on Mondays, Wednesdays, and Fridays. Observations consisted

of 1.5 hr sessions that began between 1430 and 1630 hr. Bears were typically on exhibit

together, with one observer tracking one bear, while another observer tracked the other.

Table 1 displays the final ethogram used, consisting of 21 behaviors divided into 7

classes. For the purpose of this study, most of the data were analyzed and presented

graphically in terms of these classes. Five of these classes of behavior were mutually

exclusive, while 2 of the classes (Groom and Food Directed behaviors) were coded in

conjunction with behaviors from the other five classes. This ethogram was developed

prior to the study, based on observations and notes taken for several months.

Researchers involved in the project initially learned the definitions and

abbreviations for each of the behaviors listed in Table 1. Following their ability to state

the important observable events of each definition, they were trained to identify the

behaviors by watching video examples. This was later paired with learning to use the

palm pilots and reference cards to successfully code the behaviors. The third stage of

their training process involved practice observations of the live polar bears while using

the palm pilots and reference cards. The entire training process took several weeks, and

following training (when they began real data collection), researchers were monitored for

errors in their data collection, such as coding two mutually exclusive behaviors

simultaneously. Actual and hypothesized errors in coding were discussed during weekly

group meetings. This process was used for training all new researchers, and for all

experiments listed in this set of studies.

For purposes of coding the bears' location, the exhibit was divided into the 5

areas shown in Figure 2. Instantaneous time samples (Altmann, 1973) were taken every

15 s for 1.5 hr, with a total of 360 samples per subject per session. Researchers coded behaviors using synchronized stop watches, data sheets, palm pilots, and laminated cards displaying the abbreviations, behaviors, and definitions listed in Table 1. Each observer coded only one bear as they viewed it from the public area of the exhibit. On days when more than one observer per bear was present, those additional researchers were assigned to take reliability data. A notebook was always available to record the date, time, session, participating researchers, notable behaviors and the particular times at which they occurred, or any issues that arose. A within-subject reversal design (order described below) was used for the following four conditions:

Baseline (BL) – No food was presented during the 1.5 hr observation.

Fixed-Time 1 min (FT1') – One capelin was thrown per bear every 1 min during the middle ½ hr of observation (30 capelin per bear).

Fixed-Time 5 min (FT5') – One capelin was thrown per bear every 5 min during the middle ½ hr of observation (6 capelin per bear).

Fixed-Time10 min (FT10') – One capelin was thrown per bear every 10 min during the middle ½ hr of observation (3 capelin per bear).

When food was to be presented to a particular bear, the researcher observing that bear typically carried the food bucket to their observation point, and then threw the capelin at appropriate intervals directly into the area where the target bear was located. This was done to avoid any conflict over the food items between the bears. Throughout the study, several design reversals were run, with no more than 2 Fixed-Time conditions run before returning to Baseline. The order of conditions was:

BL/FT5'/FT1'/BL/FT1'/FT10'/BL/FT5'/FT10'

Except for the initial BL condition (9 days for each bear), the remaining conditions were 6 days each. This produced a total of 57 sessions for Tundra. Because Pasha died unexpectedly shortly before the reintroduction of the FT1' condition, only 27 sessions were conducted for this bear, consisting of BL, FT5, FT1, BL. Pasha's death was produced by preventive surgery for a condition that had no observable bearing on his behavior on exhibit, so his data were kept. Prior to collapsing the data over days for each condition, data for each class of behavior for Tundra were assessed by comparing the means and standard errors of the first 6 days a treatment condition was run (initial implementation of the condition) to the last 6 days run for that condition (the return to that condition). This was also done for the Baseline data for both bears by comparing the means and standard errors of the first 9 days of baseline to the second and third set of 6 days (Pasha's comparisons involved first 9 days BL to second 6 days BL). All results showed few differences between the initially run and later run observations of a condition, regardless of when it occurred. Therefore, I collapsed the data across all observations of a condition.

Interobserver agreement (IOA) was calculated based on total agreement (Poling, Methot, & LeSage, 1995) for 25% of all sessions conducted. This produced a percentage of agreement for each of the seven classes of behavior. Because Pasha died early during the experiment (and thus had limited reliability checks), all reliability sessions were based on Tundra's data, and accounted for 36.8% of her observation days. All measures of total agreement were above 97%.

SigmaStat 3.1® (a commercial statistical software package) was used for all statistical analyses. The data for the observed classes of behavior were split into ½ hr bins

(Before, During, and After the period during which food was delivered), and all ½ hr bins and subjects were analyzed separately. Statistical analyses were conducted on the number of days for each condition representing individual observations (N). Except for one exception (See Experiment 1's Food Directed Behaviors and Eating section in the Results below), all statistical analyses were conducted on individual subject's data. This was done to avoid any suggestions of increased external validity based on a limited number of subjects x number of days each subject was observed (see Swaisgood & Shepherdson, 2005 for a review). This was also the case for all of the following experiments in this study.

Because the sample size for the Baseline condition was not the same compared to each of the treatment conditions, and because some of the data did not pass normality and/or equal variances, planned comparisons were conducted between Baseline and each of the three treatment conditions. For Tundra, a standard repeated-measures ANOVA with experimental condition as the blocking variable was used to examine treatment differences. When significant differences (p < .05) for the ANOVA's were found, or when the data approached significance (p < .10), post-hoc pairwise comparisons (using Student Newman-Keuls tests) were used to determine which of the three experimental conditions significantly differed. For Pasha, who only experienced two treatment conditions, a planned comparison in the form of a t-test was conducted between the two treatment conditions. Data that did not pass normality and/or homogeneity of variance tests were analyzed using a Friedman's nonparametric repeated-measures ANOVA or a Mann-Whitney U-test.

Entropy

To provide a measure of overall use of the area in the enclosure, the randomness (Entropy) of time spent by the polar bear in the five different areas of the exhibit was calculated for each condition (Shannon, 1948). Entropy (H) is a measure of the degree of randomness in a set of variables. In this paper, I used Entropy to measure the extent to which the animal's distribution of time across the five areas of the exhibit shown in Figure 1 was random. Measures of Entropy were generated using the formula

$$H = -\Sigma \, p(i) \log p(i)$$

where $p(i)$ is the proportion of time spent in i_{th} area. Calculated values range from 0 to 1 where 0 indicates the least variable use of the enclosure and 1 indicates the most variable use of the enclosure.

Transitions between Foraging and Non-Foraging Behaviors

To examine the transitions between foraging and non-foraging behaviors (i.e., non-search, stereotyped general search, non-stereotyped general search, and focal search behaviors) during the different treatment conditions, I examined line plot changes in the mean frequency of occurrence for classes of behavior within each Fixed-Time food interval. This was done by producing a mean score at each 15 s recording interval for all possible samples of a FT schedule. For example, during the FT1' schedule, we recorded a behavior for each 15 s sampling period following the delivery of food for all FT1' condition days, thus producing 12 days x 30 samples (30 fish thrown) for the intervals 15, 30, 45, and 60 s after a fish was thrown. The end interval (60 s) marked the next fish thrown. The same procedure was used for the FT5' and FT10' schedules, with their endpoints reaching 5:00 and 10:00 min, respectively. I observed the same classes of Stereotypies and Inactive behaviors used previously. The Active class of behaviors was

divided into Active behaviors that included movement (Active) and those that did not

involve locomotion, such as standing and rearing (Nonmovement). These were placed in

a separate class because I hypothesized that they represented focal foraging strategies, as

opposed to the other Active behaviors, which were more likely to represent non-

stereotyped general search strategies.

Results/Discussion

Figure 3 shows for Tundra the mean percentage of occurrence of three classes of

behavior (Active, Inactive, and Stereotypy) across all four conditions (BL, FT1', FT5',

and FT10'). The top graph shows the results in the ½ hr before a food schedule was

introduced (Before period), the middle graph the results in the ½ hr during the

implementation of a food schedule (During period), and the bottom graph the results in

the ½ hr after the implementation of a food schedule (After period).

Tundra's Before Period

There were significant differences in Active behaviors during the Before period.

All three of the Fixed-Time conditions were significantly higher compared to Baseline

(for FT1', $t(31) = \pm3.318$, $p = .002$ (two-tailed), $d = .882$; for FT5', $t(31) = \pm2.722$, $p =$

.011 (two-tailed), $d = .694$; for FT10', $t(31) = \pm3.295$, $p = .002$ (two-tailed), $d = .877$).

This increase in Active behaviors compared to Baseline suggests that Tundra was able to

predict the upcoming food schedules, most likely by the visual presence of the observers

with fish buckets and/or the smell of the fish. This ability to predict the upcoming food

schedules was sufficient to increase non-stereotypic activity.

Tundra's During Period

There were significant differences among Stereotypies, Inactive Behaviors, and Active Behaviors during tests. Stereotypies significantly decreased compared to Baseline during the FT1' condition ($U = 137.5$, $df = 31$, $p = .013$), and the change compared to Baseline approached significance for the FT5' condition ($U = 158.5$, $df = 31$, $p = .092$). There was also a significant difference in Stereotypies between the food schedules ($F_{2, 33} = 3.662$, $p < .042$), $d = .465$. The FT1' condition produced a significantly greater reduction in Stereotypies compared to the FT10' condition ($p = .033$). The FT1' condition produced a decrease that approached significance in Inactive behaviors when compared to Baseline ($U = 159.5$, $df = 31$, $p = .099$).

Finally, Active behaviors significantly increased when comparing all of the food schedules to Baseline (for FT1', $t(31) = \pm10.925$, $p < .001$ (two-tailed), $d = 1$; for FT5', $t(31) = \pm5.784$, $p = < .001$ (two-tailed), $d = 1$; for FT10', $t(31) = \pm5.797$, $p < .001$ (two-tailed), $d = 1$). There were also significant differences between the three food schedules ($X^2 = 10.167$, $df = 2$, $p = .006$). The FT1' condition produced a significantly greater increase in Active behaviors compared to both the FT5' condition ($p < .05$) and the FT10' condition ($p < .05$).

The decreases in Stereotypies and Inactive behaviors while Active behaviors increased in the During period shows that the food schedules were effective at disrupting stereotypic activity while increasing non-stereotypic activity. The most dense schedule (FT1') was the most effective at both reducing stereotypic activity and at increasing non-stereotypic activity, whether measured in terms of the greatest decreases and increases in those behaviors observed, or in observing significant differences in those behaviors when

compared to the FT10' condition (for Stereotypies) and for both the other food schedules (for Active behaviors).

Figure 4 shows the mean percentage of occurrence for Pasha for three classes of behavior (Active, Inactive, and Stereotypy) across all three conditions (BL, FT1', and FT5'). The top graph represents the results in the ½ hr before a food schedule was introduced (Before period), the middle graph represents the results in the ½ hr during the implementation of a food schedule (During period), and the bottom graph represents the results in the ½ hr after the implementation of a food schedule (After period).

Pasha's Before Period

Only one significant difference was observed for Pasha during the Before period. Active behaviors during the FT5' condition were significantly greater when compared to Baseline, $t(19) = \pm 2.674$, $p = .015$ (two-tailed), $d = .655$. While FT1' produced greater Active behaviors compared to Baseline, and both FT1' and FT5' produced decreases in Stereotypies compared to Baseline, these findings were not significant. Part of the difficulty is that, because Pasha only received 6 days of each food condition (Tundra received 12 days of each food schedule), this did not produce enough data to obtain statistically significant differences. However, like Tundra, the decreases in Stereotypies and increases in Active behaviors for both food conditions, compared to Baseline, indicates that Pasha was able to predict the upcoming food schedules used in the following period of observation. That is, this decrease in Stereotypies and increase in Active behaviors compared to Baseline in the Before period suggests he anticipated the upcoming food schedules in the During period.

Pasha's During Period

Active behaviors significantly increased compared to Baseline during the FT1'

condition in the During period ($U = 100$, $df = 19$, $p = .009$), and during the FT5'

condition, $t(19) = \pm2.578$, $p = .018$ (two-tailed), $d = .616$. Similar to the Before period,

there were also decreases in Stereotypies when comparing both food conditions to

Baseline. However, these results were not statistically significant (see previous paragraph

for why this was likely the case).

The increase in Active behaviors accompanied by a nonsignificant decrease in

Stereotypies suggests that the food schedules were effective at disrupting stereotypic

activity while increasing non-stereotypic activity. Unlike Tundra, for Pasha both the FT1'

and FT5' condition were equally effective at reducing Stereotypies. However, like

Tundra, the FT1' schedule for Pasha produced the greatest increase in Active behaviors.

This gives further support to the findings reported for Tundra that the densest schedule

was the most effective at increasing Active behaviors.

Pasha's After Period

There were significant differences in Stereotypies and Inactive behaviors during

the After period. Stereotypies significantly decreased compared to Baseline during the

FT5' condition, $t(19) = \pm2.371$, $p = .028$ (two-tailed), $d = .526$, and during the FT1'

condition the difference between FT1' and Baseline approached significance, $t(19) =$

±1.964, $p = .064$ (two-tailed), $d = .348$. Inactive behaviors significantly increased

compared to Baseline during the FT5' condition, $t(19) = \pm2.849$, $p = .01$ (two-tailed), $d =$

.723, and during the FT1' condition the difference between FT1' and Baseline

approached significance ($U = 88.5$, $df = 19$, $p = .087$).

The increases in Stereotypies and decreases in Inactive behaviors in food schedules relative to Baseline were directly related to the prior feeding schedules. After the schedules were introduced, rather than returning to stereotypic activity, as Tundra did, Pasha would typically fall asleep. Therefore, from the point of view of an educational exhibit, the decrease in Stereotypies during this condition was not a positive outcome. Pasha simply switched the undesirable response of stereotypic activity for the nearly equally undesirable response of being inactive.

Tundra's Grooming

Tundra showed significant increases in Groom in both the Before and During periods. Groom in all three food conditions were significantly greater than Baseline during the Before period (for FT1', $U = 272$, $df = 31$, $p = .011$; for FT5', $U = 276$, $df = 31$, $p = .007$; and for FT10', $U = 257$, $df = 31$, $p = .049$). All three food conditions were also significantly greater compared to Baseline in the During period (for FT1', $U = 278$, $df = 31$, $p = .006$; for FT5', $U = 258$, $df = 31$, $p = .045$; for FT10', $U = 289$, $df = 31$, $p = .002$).

In both periods, near equal amounts of Licking Paws/Body and Scratching Body behaviors made up the Groom class of behaviors, and both periods showed an increase in the Groom behaviors up to the longest food interval. For example, in the During period, Mean % Groom behaviors during BL ($M = 1.1$) increased during FT1' ($M = 4$), FT5' ($M = 6.2$), and FT10' ($M = 9.3$). Ian Stirling (1988) suggests that washing followed by feeding is an important action for polar bears. He states that this behavior occurs 20 to 30 minutes following a feeding period, and that in the summer polar bears use pools of water to rinse and lick their paws (similar to our coded Licking Paws/Body behavior), and in

the winter, when water isn't available, they rub their heads and backs in the snow (similar to our coded Scratching Body behavior). Therefore, Groom behaviors do appear related to the overall polar bear foraging sequence, and were equally used in a similar fashion when a polar bear was able to predict an upcoming feeding schedule (i.e., during the Before period). It may also be that these behaviors, in captivity, occur in a stereotypic fashion.

Food Directed Behaviors and Eating

Since Eating was coded as a Food Directed behavior, this class of behaviors obviously increased during the Fixed-Time schedules in the During period. One question, however, is whether the non-eating Food Directed behaviors (Licking Air and Sniffing) increased as well. This would suggest that both behaviors are, in fact, Food Directed behaviors that occur around polar bear feeding times. To test this, I examined increases in non-Eating Food Directed behaviors to Baseline during the FT1' condition, when the most food was thrown.

Because the distributions were skewed, and because of the limited data, I combined both bears' data and compared medians as reported in Table 2. Food Directed behaviors without Eating did significantly increase compared to Baseline ($U = 626$, $df = 54$, $p = .017$). Pasha also showed significant increases for the Fixed-Time schedules in Food Directed behaviors compared to Baseline during the Before and After period, when no food was available to eat. In the Before period, Food Directed behaviors approached a significantly greater increase compared to Baseline for FT1' ($U = 91.5$, $df = 19$, $p = .052$), and there was a significant increase compared to Baseline for FT5' ($U = 92$, $df = 19$, $p = $

.047). In the After period, Food Directed behaviors were significantly greater compared to Baseline for FT1', $t(19) = \pm 4.447$, $p < .001$ (two-tailed), $d = .991$.

Both increases in non-Eating Food Directed behaviors in the During period and the increases in Pasha's Food Directed behaviors in the periods immediately prior to and after the food schedules compared to Baseline suggest that Licking Air and Sniffing are controlled by the presence of food. In the wild, both behaviors help polar bears locate prey, and the prevalence of these behaviors in captivity suggests that prior to, during, and following food, polar bears actively search for the location of food. In short, even the predictable delivery of small amounts of food can get captive polar bears to actively search their enclosure area (via sniffing and air licking).

Entropy (Variability of Enclosure Use)

As noted previously, Entropy represents a single measure of the variability of enclosure use by each polar bear. Entropy was measured during this experiment because it provided a means of assessing search strategies during the different conditions. For example, polar bears that engage in high frequencies of stereotypic activity or inactivity (as we observed during Baseline) should use few areas of their exhibit. Stereotypies, while hypothesized to be a general search foraging activity (foraging loop), tend to occur repetitively in a small fraction of an exhibit for extended periods of time, rather than across an entire exhibit. Non-stereotyped general search activity, however, should involve greater locomotion throughout their exhibit, since such general search behaviors in polar bears and other large carnivores typically involve traveling long distances for food. Finally, focal search behaviors should again limit the variability in enclosure use by the polar bears, since these behaviors would involve waiting or searching a limited area

for potential prey. Thus, I expected the FT5' and FT10' schedules to increase Entropy

scores compared to baseline, but the FT1' schedule to have little effect.

Figure 5 shows mean Entropy scores for both bears and for all three periods of

observation (Before, During, and After). The top graph shows Tundra's mean Entropy

scores, while the bottom graph shows Pasha's mean Entropy scores.

Before Period and Entropy

In the Before period, both Tundra and Pasha showed increased Entropy scores for

some of the food schedules compared to Baseline. For Tundra, both the FT5' and FT10'

conditions were significantly greater compared to Baseline (for FT5', $t(31) = \pm4.008$, $p =$

$< .001$, $d = .976$; for FT10', $t(31) = \pm2.382$, $p = .024$, $d = .548$). FT1', however, was not

significantly different compared to Baseline. For Pasha, the FT5' condition was

significantly different compared to Baseline, $t(19) = \pm2.929$, $p < .009$ (two-tailed), $d =$

.752, and FT5' being greater than FT1'approached significance, $t(10) = \pm1.970$, $p < .077$

(two-tailed), $d = .325$.

Both Tundra and Pasha's mean Entropy scores suggest that, like the decreases in

Stereotypies and increases in Active behaviors during the Before period, both bears

predicted some of the upcoming food schedules by using more of their enclosure

(increasing the variability of their overall enclosure use), which was likely a result of

searching for potential food. However, as predicted, the densest food schedule, FT1', did

not increase overall enclosure use.

During Period and Entropy

In the During period, both Tundra and Pasha showed increased Entropy scores for

some of the food schedules compared to Baseline. For Tundra, both the FT5' and FT10'

conditions were significantly greater compared to Baseline (for FT5', $U = 299.5$, $df = 31$, $p < .001$; for FT10', $t(31) = \pm 3.677$, $p < .001$, $d = .945$). There were also significant differences between the three Fixed-Time conditions ($F_{2, 33} = 7.843$, $p < .003$), $d = .891$). Both FT5' ($p = .005$) and FT10' ($p = .004$) were significantly greater than the FT1' condition. For Pasha, both the FT1' and FT5' conditions were significantly greater compared to Baseline (for FT1', $t(19) = \pm 2.631$, $p = .016$, $d = .637$; for FT5', $t(19) = \pm 4.357$, $p < .001$, $d = .988$).

Tundra's mean Entropy scores suggest that, as observed in the Before period, she used more of her enclosure during the FT5' and FT10' conditions, but not during the FT1' condition. Again, this is likely because the densest schedule produced more focal search foraging behaviors that limited Tundra from leaving an area where food was previously thrown to. It's not clear why the same effect was not observed for Pasha. While the FT5' condition did produce a greater mean Entropy score than the FT1' condition, the FT1' condition was still significantly greater compared to Baseline.

After Period and Entropy

In the After period, both Tundra and Pasha showed a decreased mean Entropy score for one of the Fixed-Time conditions compared to Baseline. For Tundra, there was a decrease in the mean Entropy score during the FT1' condition that approached significance when compared to Baseline, $t(31) = \pm 1.930$, $p < .063$, $d = .344$. For Pasha, there was a significant decrease in the mean Entropy score during the FT5' condition when compared to Baseline, $t(19) = \pm 2.798$, $p < .011$, $d = .704$.

As noted previously, after the food schedules (After period), Pasha would typically fall asleep, and thus show an increase in Inactive behaviors. While Tundra did

not increase Inactive behaviors in the After period, these results suggest that she did decrease her overall enclosure use, and thus, a decrease in moving around the exhibit. Therefore, these results suggest that at least some of the food schedules moved the bears not only out of stereotypical foraging behavior, but into non-search behaviors as well.

Transitions Between Foraging and Non-Foraging Behaviors

Figure 6 represents the mean percentage of occurrence at each of the 15 s pinpoint samples within each of the three food schedules (FT1', FT5', and FT10'). This was done to examine changes between foraging strategies during the various interfood intervals of the three Fixed-Time schedules. I expected denser schedules, like that of the FT1' and FT5' conditions, to produce relatively stable levels of responding. However, I expected that the longest interfood interval, that created by the FT10' condition, would allow an interval long enough to see transitions from the Nonmovement behaviors (focal search; Nonmovement behaviors are Active behaviors that did not involve locomotion, like Standing) to Active behaviors (non-stereotyped general search) to Stereotypies (stereotyped general search) and Inactive behaviors (non-search behaviors).

FT1'

During the FT1' conditions, Active behaviors remained the highest occurring class of behaviors for both polar bears. Nonmovement behaviors remained relatively stable for both bears at mean occurrences of near 20% throughout the interval. It's not clear why Active behaviors were much higher than the hypothesized more focal search-oriented Nonmovement behaviors. However, it does appear that, while the FT1' condition did limit the variability of enclosure use for both bears during the Before period

and for Tundra in the During period, that a considerable amount of non-stereotyped movement was created by such a schedule.

FT5'

The FT5' condition, while maintaining relatively stable levels of responding for both bears throughout the interfood interval, did show some transitions of interest. For both bears, Nonmovement behaviors began high and quickly diminished below 20%. For Tundra, Nonmovement behaviors recovered to near 40% on the last interval, when fish was thrown. Active behaviors and Stereotypies remained relatively stable for both bears, while Inactive behaviors showed a gradual increase that peaked near min 3:00 for Tundra and near min 4:00 for Pasha, and then gradually declined.

FT10'

As expected, the FT10' condition produced an interfood interval long enough to show transitions between the focal, non-stereotyped general, stereotyped general, and non-search behaviors. Nonmovement behaviors (focal search) and Active behaviors (general search) both show their highest peaks at the times prior to and just after a fish delivery (min 10:00). While Nonmovement behaviors show a quick decline, with mean levels of responding below 10%, Active behaviors remained relatively high for the first several minutes. As Active behaviors begin to drop, Stereotypies begin to increase, peaking around min 7:00, followed by a gradual decrease as Active behaviors begin to peak again. Inactive behaviors remain relatively low throughout the interfood interval, but do gradually increase towards min 4:00, followed by a gradual decrease.

The length of the interfood interval did allow us to see transitions between the various search states and non-search behaviors. Both focal search (Nonmovement) and

non-stereotyped general search (Active) behaviors began at relatively high levels, with the focal search behaviors showing a sharper decline compared to the general search behaviors. When the general search behaviors did begin to decline, stereotyped general search (Stereotypies) and non-search (Inactive) behaviors began to occur. This order of events showed a similar reversal of the search patterns, as would be expected in any sequence of search behaviors. These data also lend further support to the notion of stereotypic activity occurring as a result of a stereotyped general search "foraging loop", where many carnivore stereotypic activities increase over time towards an entrained large feed, and continue to occur in the absence of any focal stimuli that lead to the consumption of food.

<div align="center">Experiment 2</div>

In Experiment 1, I examined the effects of three Fixed-Time food schedules (FT1', FT5', and FT10') on several classes of behavior and the variability of enclosure use with two polar bears. However, there is a difficulty in suggesting that food on particular Fixed-Time schedules produces some sort of change as a result of that schedule, and more specifically, the focal stimuli associated with the periodic delivery of food. Food itself may produce these effects, regardless of how it is delivered. Stereotypies may decrease and other non-stereotyped behaviors increase as a result of being fed, rather than being fed periodically.

The purpose of Experiment 2 was to examine this alternative explanation of the results demonstrated in Experiment 1. I examined three food controls that delivered the same amount of food used in each of the three food schedules, but delivered that amount of food at one time and at the beginning of the During period, rather than throughout that

period of observation. I expected that the three food schedules would produce greater reductions in Stereotypes and greater increases in Active behaviors compared to controls in both the Before and During periods of observation.

Methods

Subjects and Enclosures

Tundra from Experiment 1 was observed in Experiment 2. She was the only bear living in the exhibit at the time of the study. The enclosure was the same as used during Experiment 1.

Materials

Materials were the same as Experiment 1, with the exception that data sheets and clipboards were now completely replaced with new PDAs: the Palm™ Vx.

Data Collection and Procedures

The ethogram was the same as used during Experiment 1. Observations were conducted from March 2004 through April 2004. A total of 4 researchers were involved in the total data collection. Observation methods, times and days of observations were the same as Experiment 1. Due to a lack of time, only four days of observations were collected for each condition, which were as follows:

> *Control 1 min (C1') –* The control for FT1', where 30 capelin were thrown at the start of the During period (min 30:00).

> *Control 5 min (C5') –* The control for FT5', where 6 capelin were thrown at the start of the During period.

> *Control 10 min (C5') –* The control for FT10', where 3 capelin were thrown at the start of the During period.

All four days of data collection per condition were taken in a row and in the following order: C10' – C5' – C1'

Interobserver agreement (IOA) was calculated based on total agreement (Poling, Methot, & LeSage, 1995) for 25% of all sessions conducted. This produced a percentage of agreement for each of the seven classes of behavior. All measures of total agreement were above 85%.

Because of the limited number of data collection days per condition, I examined differences in the control and Fixed-Time conditions by graphically comparing the means and standard errors observed. Baseline from Experiment 1 was also included in the results as a reference point.

Results/Discussion

Figure 7 shows the mean percentage of occurrence for Tundra for three classes of behavior (Stereotypy, Inactive, and Active) across Baseline (black circle), the three Fixed-Time schedules (FT1', FT5', and FT10'; open squares), and the three Control schedules (C1', C5', and C10'; open triangles). The top graphs represent the Stereotypies in the Before (left graph) and During period (right graph), the middle graphs represent Inactive behaviors in the Before and During period, and the bottom graphs represent Active behaviors in the Before and During period.

Stereotypies

For both the Before and During periods, the FT schedules showed greater reductions in Stereotypies when compared to all three Control conditions. In the During period, the greatest reduction in Stereotypies was during the FT1' condition ($M = 6.1$, *SE* $= 2.3$). Control conditions showed similar levels of Stereotypies in the Before period, and

a small decrease in Stereotypies in the During period when compared to Baseline. The one exception to this occurred for the C5' condition in both periods, where Stereotypies were greater compared to Baseline. However, this appeared to be combined with a lack of Inactive behaviors during the C5' condition. Therefore, it does not appear that the C5' condition caused an increase in Stereotypies, but rather, that during those 4 days of observation, Tundra engaged in more Stereotypies because of a lack of Sitting or Lying Down.

Inactive Behaviors

While there were small reduction in Inactive behaviors in the During period, both the Fixed-Time and Control conditions produced similar results. As noted previously, there was the exception observed in the C5' condition, but this did not appear to be a result of the schedule. The largest real difference observed was in comparing the FT1' condition's Inactive behaviors ($M = 13.9$, $SE = 5.4$) to the Inactive behaviors observed during the C1' condition ($M = 29.8$, $SE = 19.3$).

Active Behaviors

The were several differences between the Fixed-Time and Control conditions in both the Before and During period for Active behaviors. While the Control conditions did increase Active behaviors compared to Baseline in both periods, the increases observed during the FT conditions were greater. The increase observed for the FT10' schedule in the Before period, and for the FT1' and FT5' in the During condition, did not show overlapping standard error bars with their comparable Control condition. The greatest of these differences was for FT1' in the During period (FT1', $M = 78.4$, $SE = 4.5$; C1', $M = 38.3$, $SE = 8.6$).

These results clearly and consistently show that the Control conditions were not as effective at reducing Stereotypies and Increasing Active behaviors as the Fixed-Time schedules. Therefore, food alone was not a sufficient condition for disrupting stereotypic activity and increasing non-stereotypic activity. The schedules themselves played an important role in decreasing stereotypic activity and increasing non-stereotypic activity, as was predicted by the foraging loop hypothesis, and a foraging systems view of stereotypic activity. The repeated presence of focal stimuli that can be consumed, as was presented on the Fixed-Time schedules, consistently pushed the bears out of stereotyped general search behavior (i.e., foraging loop behavior), and into non-stereotyped general search and focal search behaviors.

<div align="center">Experiment 3</div>

As noted previously, making a daily feeding time less predictable has been shown to reduce stereotypic activity (Bloomsmith & Lambeth, 1995). This fits with a behaviors systems approach to foraging and stereotypic activity, since stereotypic activity in many species of carnivore and omnivore should increase to a large predictable daily feed, and making that feeding time less predictable should reduce the ability to anticipate that point in time, and thus reduce pre-feeding stereotypic activity.

In Experiment 3, I used Variable-Time (VT) schedules similar to the Fixed-Time (FT) schedules used in Experiment 1. These VT schedules delivered food at variable times around an average time of delivery. Because the VT schedules should make the delivery of the small food items less predictable, I expected little to no decreases in Stereotypies and increases in Active behaviors during the time prior to a feeding schedule (Before period), as was observed in Experiment 1. The limited ability to predict an

upcoming schedule should cause a polar bear to ignore the focal stimuli, such as scent, that previously reliably predicted an upcoming feeding time. The decreases in Stereotypies and increases in Active behavior while the VT schedules were in effect (During period) should be similar to those observed for the FT schedules during Experiment 1.

Because the VT schedules should make the most dense schedule, VT1', less predictable, I also expected Entropy (variability of enclosure use) scores to be significantly greater than baseline in the During period. In Experiment 1, the FT1' schedule, while producing the greatest reductions in Stereotypies and greatest increases in Active behaviors for Tundra, did not significantly increase Tundra's variability in enclosure use in the Before and During periods. However, the lack of predictability by a similar dense Variable-Time schedule should cause Tundra to spend more time investigating other parts of an exhibit where food did not occur.

Methods

Subjects and Enclosures

Tundra from Experiment 1 and 2 was observed in Experiment 3. She was the only bear living in the exhibit at the time of the study. The enclosure was the same as used during Experiment 1 and 2.

Materials

Materials were the same as Experiment 1 and 2. The palm pilots were the same as used in Experiment 2.

Data Collection and Procedures

The ethogram was the same as used during Experiment 1 and 2. Observations were conducted from June 2004 through November 2004. A total of 7 researchers were involved in the total data collection. Observation methods, times and days of observations were the same as Experiment 1 and 2, with three exceptions, collected on either a Saturday or Thursday.

Variable-Time (VT) schedules were used in this experiment. The VT schedules were similar to a Fixed-Time (FT) schedule, with the exception that food was thrown at variable times based on an average time. For instance, a VT-5 min schedule would result in a capelin being thrown on average every 5 minutes, but with a range from 15 s to 9 min 45 s after the last fish was thrown. The VT schedules were generated randomly in an Excel file based on a fish being thrown at 15 s intervals. This order was also run backwards, and the days in which the forward or backward order of the pre-generated VT schedules were alternated session by session.

A within-subject reversal design (order described below) was used for the following three conditions:

Baseline (BL) – No food was presented during the 1.5 hr observation.

Variable-Time 1 min (VT1') – One capelin was thrown to Tundra on average every 1 min (range = 15 s – 1 min 45 s) during the middle ½ hr of observation (30 capelin).

Variable-Time 5 min (VT5') – One capelin was thrown on average every 5 min (range = 15 s – 9 min 45 s) during the middle ½ hr of observation (6 capelin).

Throughout the study, several design reversals were run. The order of conditions was: BL/VT5'/VT1'/BL/VT1'/VT5'

All conditions were run for 4 days each, and a second 4 days when repeated. This produced a total of 24 sessions for Tundra. Similar to Experiment 1, prior to collapsing the data over days for each condition, data for each class of behavior for Tundra were assessed by comparing the means and standard errors of the first 4 days a treatment condition was run (initial implementation of the condition) to the last 4 days run for that condition (the return to that condition). All results showed few differences between the same condition, regardless of when it occurred. Therefore, I collapsed the data by conditions.

Interobserver agreement (IOA) was calculated based on total agreement (Poling, Methot, & LeSage, 1995) for 25% of all sessions conducted. This produced a percentage of agreement for each of the seven classes of behavior. All measures of total agreement were above 85%.

SigmaStat 3.1® was used for all statistical analyses. The data for the observed classes of behavior were split into ½ hr bins (Before, During, and After the period during which food was delivered), and all ½ hr bins were analyzed separately. A standard repeated-measures ANOVA with experimental condition as the blocking variable was used to examine condition differences. When significant differences ($p < .05$) for the ANOVA's were found, or when the data approached significance ($p < .10$), post-hoc pairwise comparisons (using Student Newman-Keuls tests) were used to determine which of the three conditions significantly differed. Data that did not pass normality and/or homogeneity of variance tests were analyzed using a Friedman's nonparametric repeated-measures. Entropy was also examined, and was measured the same as it was in Experiment 1.

Results/Discussion

Figure 8 shows the mean percentage of occurrence for Tundra for three classes of behavior (Stereotypy, Inactive, and Active) across all three conditions (BL, VT1', and VT5'). The top graph represents the results in the ½ hr before a food schedule was introduced (Before period), the middle graph represents the results in the ½ hr during the implementation of a food schedule (During period), and the bottom graph represents the results in the ½ hr after the implementation of a food schedule (After period).

Before Period

As expected, no significant differences were observed in the Before period of observation. Because the VT schedules made food less predictable, this appeared to eliminate any reductions in anticipatory Stereotypies or increases in anticipatory Active behaviors.

During period

Stereotypies

No significant changes were observed in Stereotypies in the During period. While the VT1' schedule did eliminate Stereotypies almost completely, this finding was not significant.

One difficulty with observing any significant reductions in Stereotypies during this experiment was that Stereotypies occurred less frequently during Baseline then had been observed in Experiment 1. In Experiment 1, Tundra engaged in Baseline levels of Stereotypies near 40% of the time, and in Inactive behaviors near 40% as well. In this Experiment, Tundra engaged in Stereotypies near 20% of the time during Baseline, and Inactive behaviors near 60% of the time. Therefore, this finding reflects a change in an

equally undesirable response on the part of Tundra; less Stereotypies, but more Inactive behaviors.

Inactive and Active Behaviors

As noted above, Tundra spent more of her time during Baseline engaged in Inactive behaviors compared to Stereotypies, unlike the near equal distributions of both classes of behaviors observed in Experiment 1. As a result, the VT schedules appeared to have their greatest impact on reducing Inactive behaviors and increasing Active behaviors. There was a significant reduction in Inactive behaviors during the VT schedules ($F_{2, 21} = 3.945$, $p = .044$, $d = .475$). VT1' was significantly different compared to Baseline ($p = .046$) and VT5' approached a significantly lower difference compared to Baseline ($p = .055$)

There was also a significant increase in Active behaviors in the During period ($F_{2, 21} = 30.507$, $p < .001$, $d = 1.0$). The VT1' schedule was significantly greater compared to both Baseline ($p < .001$) and the VT5' schedule ($p = .005$). The VT5' schedule was also significantly greater compared to Baseline ($p < .001$).

These results suggest that the VT schedules, like the FT schedules, had similar effects at reducing some aberrant response (in this case, Inactive behaviors rather than Stereotypies) and increasing Active behaviors in the During period. The VT1' schedule, like the FT1' schedule, showed the greatest effects at decreasing some aberrant class of behaviors and increasing Active behaviors.

After Period

Active Behaviors

The only significant result observed in the After period was a near significant increase in Active behaviors ($F_{2, 21}$ = 3.550, p = .057, d = .418). VT1' approached a significant increase compared to Baseline (p = .08).

The lack of predictability of the most dense schedule, VT1', maybe have resulted in a minimal but lingering increase in Active behaviors. Because food was less predictable under a VT schedule, this appeared to produce a lasting effect in non-stereotypic searching following the implementation of a food schedule (something that was not observed during the FT schedules).

Entropy (Variability of Enclosure Use)

Figure 9 shows mean Entropy scores for Tundra and for all three periods of observation (Before, During, and After). Only one significant difference was observed, which was for Entropy scores in the During period ($F_{2, 21}$ = 3.963, p = .043, d = .478). The VT5' schedule was significantly greater compared to Baseline (p = .030), and the VT1' schedule approached being significantly greater compared to Baseline (p = .067).

As predicted, this result gives partial support to the hypothesis that the VT1' schedule, unlike the FT1' schedule, would increase variability in enclosure use when compared to Baseline. The VT1' schedule, while giving out the same density of food as the FT1' schedule, was less predictable, and therefore appeared to encourage searching around the polar bear exhibit for food in a fashion similar to the VT5', FT5', and FT10' schedules, where the FT1' schedule limited variability in enclosure use by keeping Tundra in a small portion of her exhibit while the schedule was in effect.

Experiment 4

According to the foraging loop hypothesis of stereotypic activity, small bits of food should reduce stereotypic activity by pushing a carnivore out of stereotyped general search behaviors (i.e., pacing), and into focal search and consumption. This should work because the focal stimulus allows consumption of food, and thus a termination of the foraging sequence. What would happen, however, if a novel focal stimulus that didn't allow for consumption were introduced? It might initially push a carnivore into focal search behaviors, but without at least an occasional termination of the foraging sequence, a carnivore should either increase foraging loops in the presence of such stimuli, or rapidly habituate to the non-consumable stimulus.

In Experiment 4, we tested this hypothesis by presenting a novel food scent (fish/beef spray from a spray bottle) directly in front of the polar bear exhibit. The scents were delivered on Fixed-Time schedules similar to the FT1' schedule observed in Experiment 1, but with the end result being no contact or consumption of an item following their introduction.

Methods

Subjects and Enclosures

Tundra from the previous three experiments was observed in Experiment 4. Triton, a 9-year-old male at the start of the study, was also included in the experiment. He was born in November, 1997 at the Roger Williams Park Zoo and arrived at the Indianapolis Zoo on 3/30/2004. He weighed approximately 386 kg. The enclosure was the same as used during the three previous experiments.

Materials

Materials were the same as the three previous experiments, with the exception that the palm pilots used were Zire 21™ palm pilots. The scent used during Experiment 4 was a mixture of 75 ml fish base, 25 ml instant beef bouillon, and 250 ml water. The scent contents were therefore 3/14 fish base, 1/14 bouillon, and 5/7 water. A spray bottle was used to deliver the scents.

The scent was selected by initially piloting a number of scents with both polar bears. Scents piloted included ground sardines and anchovies, blood, vinegar, fish base, and beef bouillon. Based on both bears' initial reactions to the scents (appearing to sniff in the direction of where we sprayed), as well as the ease with which it could be sprayed, we selected both fish base and instant beef bouillon as the food scents in the study.

Data Collection and Procedures

The ethogram was the same as used during the three previous experiments. Observations were conducted from June 2006 through July 2006. A total of 5 researchers were involved in the total data collection. Observation methods and times were the same as the previous three experiments. Days in which the data were collected included Monday, Wednesday, Friday, Saturday, and Sunday.

A within-subject reversal design (order described below) was used for the following two conditions:

Baseline (BL) – No food was presented during the 1.5 hr observation. During the return to Baseline (second 5 days of BL), a spray bottle with water (control) was used in the same fashion at the Spray condition described below.

Fixed-Time 1 min (Spray) – Five sprays of the spray bottle were delivered every 1 min during the middle ½ hr of observation (30 bouts of sprays).

Throughout the study, two design reversals were run. The order of conditions was: BL/Spray/BL/Spray

All conditions were run for 5 days each, and another 5 days when returned to. This produced a total of 20 sessions for the bears. However, Tundra would not go out on exhibit each day, and as a result, was only included in 12 of the 20 observation days (5 BL and 7 Spray days). This resulted in Triton being alone on exhibit 8 days, and on exhibit with Tundra 12 days. This also resulted in us comparing Triton's behavior and enclosure use when Tundra was and wasn't on exhibit, regardless of the condition.

Similar to Experiment 1 and 3, prior to collapsing the data over days for each condition, data for each class of behavior for both bears were assessed by comparing the means and standard errors of the first 5 days a treatment condition was run (initial implementation of the condition) to the last 5 days run for that condition (the return to that condition). All results showed few differences between the same condition (including the initial Baseline condition, when no sprays were delivered, and the later 5 days of Baseline, when the control of just spraying water was used), regardless of when it occurred. Therefore, I collapsed the data by conditions.

Interobserver agreement (IOA) was calculated based on total agreement (Poling, Methot, & LeSage, 1995) for 18.8% of all sessions conducted. This produced a percentage of agreement for each of the seven classes of behavior. Because Tundra missed almost half of all sessions, she had limited reliability checks. Therefore, all reliability sessions were based on Triton's data, and accounted for 30% of his observation days. All measures of total agreement were above 96%, with two exceptions. IOA for Food Directed and Other behaviors were 70.8% and 66.7%, respectively. Because Food

Directed and Other behaviors were low in frequency (for the 12 sessions of Food

Directed and Other behaviors where reliability was measured, only 111 and 35 out of

4320 possible intervals recorded a Food Directed or Other behavior, respectively), their

importance for the study was minimal. Therefore, this discrepancy in observer agreement

when either of these classes of behavior occurred was not considered important.

SigmaStat 3.1® was used for all statistical analyses. The data for the observed

classes of behavior were split into ½ hr bins (Before, During, and After the period during

which food was delivered), and all ½ hr bins and subjects were analyzed separately.

When differences between Triton on exhibit alone (Triton Alone) and Triton on exhibit

with Tundra (With Tundra), the entire 1.5 hr of observation was condensed into one

period of observation. A standard t-test was used to examine differences between the

Baseline and Spray conditions, as well as differences between the Triton Alone and With

Tundra conditions. All results passed tests of normality and homogeneity of variance.

Entropy was also examined, and was measured the same as it was in Experiment 1.

Results/Discussion

Tundra

No significant differences were observed between the Baseline and Spray

conditions for any of the three periods of observation. While Tundra was only able to be

observed for 12 days of the 20 observation days, the standard errors of the means for each

of the classes of behavior overlapped each other between the two conditions. Therefore,

it's unlikely that even with more observations, Tundra would have shown any effect to

the Spray condition.

Triton

Figure 10 shows the mean percentage of occurrence for Triton for three classes of behavior (Stereotypy, Inactive, and Active) across both conditions (BL and Spray). The top graph represents the results in the ½ hr before the scent schedule was introduced (Before period), the middle graph represents the results in the ½ hr during the implementation of the scent schedule (During period), and the bottom graph represents the results in the ½ hr after the implementation of the scent schedule (After period).

Before Period

Stereotypies showed an increase that approached significance when compared to Baseline, $t(18) = \pm2.043$, $p = .056$ (two-tailed), $d = .380$, and Inactive behaviors showed a significant decrease in the Before period, $t(18) = \pm2.384$, $p = .028$ (two-tailed), $d = .529$.

During and After Period

There was a significant decrease in Inactive behaviors in the During period when comparing the Spray condition to Baseline, $t(18) = \pm2.173$, $p = .043$ (two-tailed), $d = .436$, and a decrease that approached significance in the After period, $t(18) = \pm1.75$, $p = .097$ (two-tailed), $d = .261$. Stereotypies increased in the Spray condition compared to Baseline for both the During and After conditions, but neither of these increases were significant or approached significant.

Spray Effects Concluded

These results, along with Tundra's lack of significant findings, support the hypothesis that presenting novel focal stimuli in the form of food scents will not decrease Stereotypies (Tundra), and may even lead to an increase in Stereotypies for some periods (Triton). While the spray did cause Triton to engage in less Inactive behaviors, this was

because the focal scents elicited an increase in at least some components of stereotyped general search behaviors.

Triton Alone vs. With Tundra

As mentioned in Experiment 4's Methods section, Triton spent 8 of the 20 observation days on exhibit alone. This was because Tundra refused to go on exhibit that day, at least in part due to the presence of Triton. Polar bears in the wild are typically solitary, and while Tundra and Pasha (the male polar bear from Experiment 1) did spend most of their exhibit time together, they had been together since they were young. Triton came to the zoo as an adult, and had only recently been exhibited with Tundra at this time.

If the interactions between Tundra and Triton were aversive in some form, I expected to see a reduction in Active behaviors and Entropy scores when Tundra was present compared to when Triton was alone on exhibit. A decrease in both these measures would suggest that Triton was using less of his overall exhibit and engaged in less desirable behaviors, presumably as a result of avoiding coming into contact with Tundra. We did not expect to see increases in Stereotypies, since those behaviors reflected foraging activity for the polar bears, and not the presumed measure of "stress" as a result of aversive social interactions.

Figure 11 shows Triton's five classes of behaviors (Stereotypy, Inactive, Social, Active, and Other) and Entropy scores for the two conditions (Triton Alone and With Tundra). The Entropy graph is on the top right, while the class of behaviors graph is along the bottom.

There was an increase in Social behaviors during the With Tundra condition that approached significance, $t(18) = \pm1.969$, $p = .065$ (two-tailed), $d = .348$. Considering no Social behaviors were possible when Triton was exhibited alone, this was not surprising.

There was a decrease in Active behaviors during the With Tundra condition that was significant when compared to the Triton Alone condition, $t(18) = \pm2.368$, $p = .029$ (two-tailed), $d = .522$. There was also a decrease in the Entropy score during the With Tundra condition that approached significance when compared to Triton Alone, $t(18) = \pm2.015$, $p = .059$ (two-tailed), $d = .368$.

These results suggest that Triton did use less of the overall enclosure and engaged in less desirable behaviors when exhibited with Tundra as opposed to being on exhibit alone. This is worth taking into account when attempting to house naturally solitary species in the same exhibit. It may be that the two polar bears would be better suited exchanging times they were on exhibit together, or housing polar bears individually as a general rule.

<div align="center">General Discussion, Polar Bears</div>

Fixed-Time Schedules and Classes of Behavior

All of the Fixed-Time schedules were effective at decreasing Stereotypies and increasing Active behaviors for both bears. This occurred both in the periods Before and During a schedule's implementation. This suggests that the locomotor stereotypic activity observed in both bears was a function of appetitive search behaviors, as the behavior systems model of stereotypic activity predicts.

Before the Food Schedules

Both Tundra and Pasha showed increases in Active behaviors in the ½ hr prior to the implementation of a food schedule (Before Period). All three Fixed-Time schedules (FT1', FT5', and FT10') increased Active behaviors for Tundra, and the FT5' schedule increased Active behaviors for Pasha. While there were decreases in Stereotypies for both bears prior to the implementation of a food schedule, they were not significant.

This increase in Active behaviors prior to the implementation of a food schedule suggests that both bears were able to anticipate the upcoming food schedules, and therefore increased non-stereotyped active searching as a result. This likely occurred because of the scent of the food in the food buckets that were to be used in the later During period, when the food schedules were implemented, or by visually identifying the researchers that would soon be throwing the food during the food schedules. Because these food scents and/or visual cues were directly correlated with the ability to later consume food on a food schedule, they appeared to function as adequate focal stimuli to move bears into non-stereotyped general search activity. Unlike scents that do not allow later consumption (See Experiment 4), or the non-novel scents of food and animals around the zoo, the focal stimuli of the food scents and/or visual cues did reliably predict an upcoming time when food could be consumed, and therefore increased Active behaviors.

During the Food Schedules

Both bears showed decreases in Stereotypies and increases in Active behaviors when the food schedules were implemented. For Tundra, the FT1' schedule decreased Stereotypies and Inactive behaviors, while increasing Active behaviors from Baseline. The FT1' schedule also decreased Stereotypies compared to the FT10' schedule, and

increased Active behaviors compared to the FT5' and FT10' schedules. The FT5'

schedule showed a decrease in Stereotypies from Baseline that approached significance,

and both the FT5' and FT10' schedules increased Active behaviors from Baseline.

Therefore, while all the food schedules were effective in at least increasing Active

behaviors, and some of the schedules were effective in decreasing Stereotypies, the

densest schedule, FT1', was the most effective of all the food schedules.

While there was a decrease in Stereotypies for Pasha, it was not significant. This

was at least in part due to the limited number of observations that were taken for Pasha,

which made finding any statistical proof of effects difficult. However, the increase in

Active behaviors from Baseline for both the FT1' and FT5' schedule suggests that the

food schedules were effective in increasing non-stereotyped search activity for Pasha as

well.

Taken together, these data provide further support for the foraging loop

hypothesis of stereotypic activity. The delivery of small food amounts was enough to

disrupt stereotypic activity and increase non-stereotyped general search behaviors.

After the Food Schedules

The only differences observed following the food schedules were for Pasha, and

this change involved a decrease in Stereotypies and increase in Inactive behaviors for

both the food schedules. Inactivity represents a "tuning out" of the environment, or non-

search behaviors. Therefore, the small amounts of food that were delivered appeared able

to halt any type of searching, stereotyped or otherwise, for Pasha, even with an upcoming

large daily feeding shortly following this period.

Grooming and Food Directed Behaviors

The extra classes of behaviors observed in this study, Groom and Food Directed behaviors, both showed important appetitive components. Food directed behaviors, even when not including Eating, increased significantly when the largest amount of food was presented (i.e., FT1' schedule). Grooming, however, appeared to increase for Tundra when the food schedules were leanest, having the longest interfood interval (i.e., FT10' schedule). Licking Air and Sniffing are important behaviors that polar bears use to locate prey in the wild. They also occurred while both the bears in this study engaged in stereotypic activity, which gives further evidence that polar bear locomotor stereotypic activity is a foraging activity.

Groom, as noted above, increased when food was more likely to not occur, but had previously occurred. These behaviors (Licking Paws/Body and Scratching Body) are important behaviors following the consumption of food. In the laboratory, post-food behaviors, such as water drinking, can be induced by particular schedules and result in polydipsia, or excessive water drinking (Lucas, Timberlake, & Gawley, 1988). Therefore, similar procedures for attempting to decrease or eliminate large carnivore stereotypic activity in captivity should take this into consideration. It may be that longer, predictable schedules of food deliveries could increase post-food behaviors like grooming, and possibly induce it regularly enough to be stereotypic, or deter the overall welfare of that exhibited animal.

Overall Enclosure Use

Both Tundra and Pasha showed increases in Entropy (variability of enclosure use) scores in the periods before and during a food schedule delivery and for some of the food schedules. However, for Tundra in both periods, and for Pasha in the Before period,

Entropy scores did not increase from Baseline for the FT1' schedule. Because this schedule was the densest of all the food schedules, I expected it to increase focal search behaviors to the point of limiting overall enclosure use, which it did. While the greatest decreases in Stereotypies and increases in Active behaviors were observed during this schedule, the frequent delivery of a food item minimized a bears' need to move around other parts of the exhibit non-stereotypically. Instead, bears were observed to limit their movements to smaller areas, as evidenced by the Baseline-comparable Entropy scores for the FT1' schedule.

Transitions between Foraging and Non-Foraging Behaviors

As predicted, the FT1' and FT5' schedules were relatively stable in classes of behaviors during all intervals recorded. During the interfood interval of the FT10' schedule, however, Tundra showed predominantly Active (non-stereotyped general search) and Nonmovement (focal search; Active behaviors without locomotion) behaviors at the beginning and end of the interval, with Nonmovement dropping and rising steeply several intervals after and before the delivery of food, respectively. Active behaviors dropped off near the middle, where Stereotypies (stereotyped general search) and Inactive (non-search) behaviors increased. These results illustrate the sequence of foraging and non-foraging behaviors within the interfood interval, with focal search behaviors transitioning to non-stereotyped search, then stereotyped search, and to some degree, non-search behaviors as well. The behavior systems model of stereotypic activity (see Figure 1) predicts this, where the focal stimulus of food disrupts the general search foraging loop, thus allowing the full foraging sequence to occur.

Surprisingly, few Nonmovement behaviors occurred during the FT1' schedule, and to a lesser extent, during the FT5' and FT10' schedules. Nonmovement was expected to represent focal search behaviors, since this class included the two Active behaviors (Standing and Rearing) that involved attentive behavior without locomotion. This was additionally surprising given the Entropy results for the FT1' schedule, which showed that an increase in focal search behaviors resulted in limited overall enclosure use.

In the wild, polar bears travel long distances searching for food. Because of their large home range size and superb sense of smell, a polar bear could be miles away from potential food or prey when coming into contact with that scent. Therefore, following the detection of a scent (focal stimulus), it's likely that the polar bear would still have to travel a significant distance before engaging in the more proximate search behaviors of stalking or capturing prey.

It may be that, unlike other large carnivores who spend less time detecting prey from long distances, polar bears engage in a considerable amount of focal search behavior that involves travel. If this were true, then this would explain why Nonmovement behaviors were less frequent than their locomotor Active behavior counterparts, and why Entropy scores were still low for the FT1' schedules. FT1' schedules produced focal movement, which would still involve locomotion, but not across varying parts of the exhibit, as non-stereotyped general search locomotion does.

Schedule Effects vs. Food as a Distractor

One alternative explanation of the effects observed during the food schedules is that, rather than transitioning polar bears out of a general search foraging loop, food simply distracted the bears from their stereotypic activity, presumably by giving the bear

something else to attend to. The same could be true of a loud sound or bright light disrupting stereotypic activity; the simple decrease of an action because of a loud sound or bright light would not allow us to conclude that a lack of loud sounds or bright lights were the motivation for engaging in the behavior to begin with. As a result, Experiment 2 examined the effects of the same amount of food as all three schedules, but delivered all at once, rather than on the Fixed-Time schedules. The results demonstrated that, while the controls were able to decrease Stereotypies and increase Active behaviors from Baseline, those effects were not comparable to the effects of the Fixed-Time schedules. It does appear that the schedules played an important role in decreasing stereotypic activity and increasing non-stereotypic activity, as the behavior systems model of stereotypic activity would predict. One large focal stimulus, such as 30 capelin delivered at once (C30' schedule), should not be able to create the intensified foraging activity that 30 capelin delivered every minute (FT1' schedule). The periodic delivery of focal stimuli that can be consumed allows for a continued search for other potential food over an extended period of time.

Predictability of Food Schedules

How predictable a food schedule is should change the ways in which a large carnivore responds to upcoming food schedules and uses its enclosure. While Fixed-Time (FT) food schedules increased foraging prior to the schedule (Before period), Variable-Time (VT) food schedules would make the ability to predict an upcoming schedule less likely. As a result, both VT schedules (VT1' and VT5') did not produce decreases in Stereotypies or increases in Active behaviors, which their counterpart Fixed-Time schedules (FT1' and FT5') did cause to occur.

Similarly, the lack of predictability of the VT1' schedule while in effect (During period) increased overall enclosure use, which the FT1' schedule did not do for Tundra. While the FT1' schedule produced a predictable schedule that encouraged the bear to remain in limited parts of its exhibit while searching and waiting for food, the VT1' schedule generated similar levels in enclosure use as the FT5', VT5', and FT10' schedules. In other words, Tundra went searching for food in other parts of the enclosure, even when this dense schedule was in place.

These results suggest that anticipation of upcoming food events plays an important role in how a polar bear responds to upcoming food events. Anticipation of a large daily feeding, according the foraging loopy hypothesis, produces increased stereotypic activity up until that large daily feed time. In this case, a lack of ability to anticipate small food events resulted in no decreases in stereotypic activity or increases in non-stereotyped search activity prior to the delivery of food, and an increase in moving around the enclosure during dense food schedules that, when predictable, limit such variability in enclosure use.

Non-Consumable Focal Stimuli

As observed throughout this study, focal stimuli play an important role in moving polar bears out of general search foraging loops (i.e., stereotypic activity), and into other search sequences, followed by consumption. But what happens when a relatively novel food scent is delivered as a focal stimulus, but does not allow for consumption of food? According to a behavior systems account of stereotypic activity, they should either have no effect, or increase the motivation to find food without allowing for consumption, and therefore increase foraging loops in the form of locomotor stereotypic activity. For

Tundra, no changes in behavior were observed as a result of the periodic (every 1 min) scent sprays. For Triton, some increases in Stereotypies, although minimal and only approaching significance in the Before period, were observed. The scent sprays decreased Inactive (non-search) behaviors, which suggests that the spray did produce an increased motivation to engage in search behaviors.

Most importantly, focal stimuli without followed consumption did not produce the decreases in Stereotypies and increases in Active behaviors and Entropy scores observed by most of the food schedules, which did produce consumable focal stimuli. Completion of a foraging sequence through some form of proximate search behavior, such as prey contact or consumption, is an important component of decreasing stereotypic activity in large carnivores.

Stereotypic Activity and Foraging

Overall, these experiments support the foraging loop model of stereotypic activity, and a behavior systems approach to stereotypic activity in large carnivores. Locomotor stereotypic activity in polar bears appears to be a direct result of the motivation to forage for prey, and should continue to occur without relevant and consumable food items presented on regular intervals.

Because polar bears are one of the most extreme of all carnivores in terms of stereotypic activity, great care should be taken when attempting to provide polar bears with enrichment or other items expected to minimize their pacing and repetitive swimming bouts. Regular deliveries of food and other focal stimuli that they can contact or consume is necessary, as is making feeding times more frequent and/or less predictable. The key to increasing both their enclosure use and non-stereotyped search

behaviors is providing focal stimuli that encourage traveling non-stereotypically around their exhibits. Because polar bears spend the majority of their time traveling, and relatively little time capturing and consuming prey, enrichment strategies should account for this and provide periodic, consumable focal stimuli, rather than items that might require excessive focal mouthing behaviors, like puzzle feeders or browse. While such devices might provide modest decreases in stereotypic activity (any presentation of food that ultimately allows for contact and/or consumption of potential prey or food should), they would be less successful than something like an automatic food delivery device, which could produce food in various parts of an exhibit and regular or irregular intervals and for lengthy periods of time.

CHAPTER 2: WALRUSES

Walruses (*Odobenus rosmarus*), like polar bears, are large carnivores. However, unlike polar bears, their individual prey most often are small bivalve mollusks (typically clams) located in concentrated "beds" on the ocean floor. The walruses actively search underwater for these food locations. Once they find food, the walruses perform a series of behaviors: disrupting the substrate with their flippers, jetting water from their mouth into the sand while probing for shellfish with their vibrissae, vacuuming up the bivalves with their mouths, and, finally, pulling the prey up and out of their protective shells using intensive concentrated sucking, consisting of sealing the mouth around the prey to prevent lessening the suction by air leakage (Kastelein, Gerrits, & Dubbeldam, 1991; Kastelein & Mosterd, 1989; Nelson & Johnson, 1987).

Because of the large size of walruses relative to their typical prey, walruses spend a considerable amount of their daily activity foraging. Thus, while they are large

predators, their foraging behavior resembles grazing-like activity similar to that of an herbivore, in which the animals consume large quantities of prey in a relatively small, patch-like area and over a lengthy period of time. Thus, as opposed to large carnivores like the polar bear, walruses should spend relatively less time attempting to locate prey (general search), and more time actively seeking located prey (focal search) and consuming them.

Captive enclosures for walruses in zoos rarely provide opportunities to engage in any of these behaviors. Pools are provided but without a sandy, manipulable substrate like the ocean floor, or artificial underwater devices that might engage similar behaviors. Food is typically presented by hand, either through training sessions, or as a large meal (Kastelein & Wiepkema, 1989; Indianapolis Zoo Marine Mammal Staff, personal communication, June, 2006). At the Indianapolis Zoo the walruses are fed several times a day, often receiving all of their diet from training sessions conducted several times a day (see methods for specifics).

Typical housing and feeding procedures for walruses frequently result in several forms of focal search stereotypies. For example, the closest I was able to get in the zoo to general search behaviors for beds of bivalves in the wild was repetitive circle swimming in the pools under conditions associated with feeding, but in the absence of the prey (however, see below and Table 3 for evidence that this behavior contains components of focal search as well). Most of the focal search behavior in the wild (such as manipulating aspects of the ocean floor with the flippers, tusks, lips, and vibrissae) appear to be replaced by stereotyped tusk rubbing and by extensive sucking on flippers or on the caulking surrounding an underwater observation window in their pool. There are very

practical reasons to try to reduce these behaviors, because these behavior can result in irritation of the walrus's skin (based on flipper sucking), and the destruction of parts of the exhibit, with potential injury to the individual walrus, in the case of sucking the caulking around an underwater observation window.

Only a handful of studies have addressed stereotypies and enrichment in captive walruses. For example, Kastelein and Wiepkema (1989) showed that offering a digging trough to captive walruses resulted in reducing stereotyped circle swimming, as would be expected if swimming behavior were typically involved in locating food deposits on the ocean floor and there was no provision in the zoo for opportunities to find food and/or manipulate the substrate. In subsequent work, Kastelein, Paase, Klinkhamer, and Wiepkema (1991) also found that time spent feeding per day was increased by delivering food periodically through food dispensers that were kept loose or anchored in the pool, but required more effort by the walrus to get the food than when the walruses were simply fed by hand.

The present study examined the effects of offering two types of foraging devices to three captive walruses at Indianapolis Zoo. Two large, thick stall mats, with and without food placed in openings in the material were offered in Experiment 5, and large plastic "boomer balls" with slots that allowed food to be shaken or sucked out were used in Experiment 6. We also intermittently measured differences in Baseline levels of activity during two different periods of time (morning and afternoon), and differences between the behavior of the juvenile walrus and the two adult walruses.

Because walruses in the wild spend a considerable portion of their day foraging for small food items, and because they are fed multiple times a day in captivity, I

assumed their activity would be relatively stable throughout the day, rather than differentially affected by a single large meal (as in the case of polar bears). In addition, because many juvenile mammals spend more time playing and investigating their environment than engaging in foraging behaviors (Fagen, 1981; Loizos, 1966), I expected that the juvenile walrus would engage in higher levels of non-stereotypic activity and lower levels of stereotypies than the adults. Other researchers have reported similar differences in the strength/frequency/persistence/variability of stereotypies between adult and juvenile mammals (Mason, 1993; Montaudouin & Le Pape, 2004, Schoenecker, Heller, & Freimanis, 2000). However, some of these researchers have suggested that the amount of time the animals have spent in captivity, rather than a difference in foraging motivation between adults and juveniles, was responsible for these differences in stereotypic activity. Therefore, I examine both possibilities in the Results/Discussion and walrus General Discussion sections.

I also expected that providing walruses enrichment in the form of the potential foraging devices that related to aspects of natural hunting behaviors (large substrate-like mats and boomer balls) would reduce stereotyped search behavior by engaging non-stereotyped general and focal search behaviors related to locating food items. Non-stereotypic activity was identified as both general and focal search because some types of swimming, like Non-patterned Swimming with Contact (see Table 3) involved vibrissae and mouth contact with a pool surface while swimming, which appeared to resemble the prey contact and extraction techniques seen on the ocean floor in the wild. It is also worth noting that Circle Swimming typically involved making a vertical loop in the pool, with the walruses swimming on their backs near the surface, and then swimming down to the

bottom of the pool while swimming forward. These events involved making vibrissae and mouth contact with both the surface of the water or the pool floor, as is later discussed in the General Discussion of Chapter 2.

Finally, I was interested in differences between the types and persistence of stereotypies each of the walruses displayed. All three walruses came from different prior habitats (see Methods below for details). Brutus, the large male in the study, showed considerably less stereotypic movement than Aurora, as observed by both keepers and a prior piloted study. This in part may be attributed to his smaller pre-existing enclosure and limited enrichment experience, and that he was trained in his prior exhibit to suck on his flipper rather than contacting/rubbing parts of the exhibit with his tusks (personal communication, Indianapolis Zoo Marine Mammal Staff, July, 2006). Therefore, I expected differences in the form of their stereotypies and the effectiveness of enrichment in general, particularly between the two adult walruses. I expected more stationary forms of enrichment, such as the large mat with food, to be most effective at reducing the more stationary forms of stereotypies exhibited by Brutus.

Experiment 5

In Experiment 5, 2 thick textured mats were introduced to the aquatic part of the exhibit under two conditions: either empty, or filled with food. The mats were initially selected because they were thick and partially compressible, thus representing an ocean floor-like substrate that the walruses could forage upon. The filled mats were expected to elicit vibrissae contact, mouthing, and sucking characteristic of niche-related foraging seen along food beds on the ocean floor; the empty mats served to control for the effects of novelty and visual-tactile interaction alone. The walruses also received food delivered

in the absence of the mats to assess the effect on the walruses of the food alone. The food alone condition also allowed us to evaluate the presentation of additional food as a potential enrichment strategy, given that prior anecdotal observations suggested a change in walrus behavior when food was delivered outside of normal feeding times. Finally, I also examined differences in baseline activity between morning and afternoon sessions, and differences between the walruses themselves. I expected their overall activity to be stable within each subject, and the juvenile walrus to engage in more non-stereotypic activity and fewer stereotypies.

Methods

Subjects and Enclosures

Three wild-born Pacific walruses (*Odobenus rosmarus*) located at the Indianapolis Zoo were used in this study. Brutus, an 18-year-old adult male at the start of the study, was collected from the wild in May of 1987 (unknown exact date and location). Originally a Sea World animal, he was originally on breeding loan from Six Flags Ohio, but became a permanent animal at the Indianapolis Zoo shortly after arrival on 10/30/03. He weighed 1076 kg at the time of the study. Aurora, a 10-year-old adult female at the start of the study, was collected from Gambel, Alaska on 5/26/95. She has been at the Indianapolis Zoo since she was several weeks old, and she weighed 521 kg at the time of the study. Nereus, a 2-year-old juvenile male at the start of the study, was found stranded in Alaska on 7/05/03. He was taken to Alaska Sea Life Center for rehabilitation and then transported to Indianapolis on 8/20/03 because he could not be released back into the wild. He weighed 236 kg.

All three walruses resided in an outdoor enclosure containing a large pool: 3.05 m deep, 20.42 m in length, 9.30 m in width, with a surface area of 427.63 m^2, and containing 370,861 L of water when filled. The walruses also could occupy a smaller land area. At 1700 hr each day, walruses were taken off exhibit to a holding area about half the size of the outdoor enclosure. Walruses were typically fed 3-5 times per day, receiving most of their diet during training sessions, some of which were broadcast publicly for educational purposes. To avoid conflict with standard training times, all conditions (described below) were conducted at standardized times between these feeding sessions. This allowed us to test at times distant enough from a training session to avoid potential satiation issues, as well as at a time they normally wouldn't receive food and were more likely to be engaged in stereotypic activity. Each walrus had its own diet; Brutus ate 35 kg of food per day, Aurora ate 11 kg, and Nereus ate 7 kg per day. Their diet consisted of herring, capelin, and clam meat.

Materials

Two 1.5 m x 1 m x 10 cm stall mats were introduced at the onset of the morning observation. Mats were constructed of a synthetic foam rubber mix, similar to a gymnasium mat, and had 25 3.17 mm holes drilled in each of them. Both mats floated in the water (on top, partially submerged). They were either introduced alone (Mat Alone condition) or stuffed with 15 capelin, 5 herring and 5 clams each (Mat with Food condition). As was the case for the polar bear observations, we also used Zire 21™ palm pilots, Timex Ironman™ repeatable countdown stopwatches, Event PC software used to collect data (developed by Dr. Jim Ha at the University of Washington for this project), laminated ethogram reference cards, and a notebook.

Data Collection and Procedures

Before beginning experimental trials, an ethogram of behaviors (with classes and definitions) was constructed (see Table 3). This ethogram is both exhaustive and mutually exclusive. Fifteen behaviors organized in 5 different classes were measured. For the purposes of this paper, most of the data were analyzed and presented graphically in terms of the classes of behaviors observed. This ethogram was developed during a previous pilot study, and modified for these experiments. Observations were conducted from July through October 2005. A total of 6 researchers were involved in the data collection. Data was taken three times per week, Tuesdays, Thursdays, and Saturdays, from July to September, and twice per week, Saturdays and Sundays, from September through October. Morning sessions (between 1030 and 1200 hr) and afternoon sessions (between 1345 and 1515 hr) were conducted for one hr each day. All experimental conditions occurred during the morning sessions, and afternoon sessions were initially collected for examining effects on treatment days that lasted longer than one hour, and later used (when no such effects were observed) to test for differences between morning baseline and afternoon activity. Instantaneous time samples (Altmann, 1973) were taken every 15 s during each 1 hr session, for a total of 240 samples per subject per session.

Researchers coded behaviors using synchronized stop watches and palm pilots displaying the abbreviations listed in Table 3. Training of researchers was similar to the description listed in the Methods section of Experiment 1. Researchers observed walruses from a catwalk above overlooking the enclosure. Observations were conducted by observers coding either Brutus and Nereus together (coding 2 walruses together), or Aurora alone. Aurora was coded alone because she traveled the largest distance across

the exhibit, thus making her the most difficult to continuously follow from the cat walk above. On days when more than two researchers were present, additional researchers were assigned to take reliability data. When mats were introduced, they were dropped by researchers into the pool from the catwalk. The mats, while large, were relatively light, and the walruses were used to receiving various enrichment items from the catwalk. Therefore, they kept a safe distance from the area in the pool that the mats were dropped into while being dropped. Additionally, a notebook was used to record mistakes with palm pilots, specific notes about walruses and keepers, and noteworthy behaviors by the walruses. A within-subject reversal design (described below) was used for the following four conditions:

Baseline (BL) – No introduction of mat or food.

Mat Alone (M) – Two 1.5 m x 1 m x 10 cm mats were introduced at the beginning of the morning observation.

Mat with Food (MF) – Both mats contained 15 capelin, 5 herring, and 5 clams each (50 food items total) stuffed in the holes in the mats.

Food Alone (F) – Same amount of food, but with food being dumped in alone at the beginning of the morning session.

Following the second BL condition, the MF and M conditions were reversed to control for potential order effects. The order was BL/M/MF/BL/MF/M/F/F. Eight sessions were run (four sessions for each of the two times a condition was presented), for a total of 32 sessions. Prior to collapsing the separately run days for each condition, data for each class of behavior were assessed by comparing the means and standard errors of the first 4 days of a condition to the same measures for the last 4 days run for that

condition (return to condition). Except for one case (see Baseline vs. Mat Alone results below), all conditions showed very similar results regardless of when it was run. Therefore, I collapsed the data within specific conditions to form a single set of the different test conditions.

Interobserver agreement (IOA) was calculated based on total agreement (Poling, Methot, & LeSage, 1995) for each walrus for 28% of all sessions conducted. This produced a percentage of agreement for each of the classes of behaviors observed and for each walrus. All measures of total agreement were at least 80%, with two exceptions. IOA for Inactive behaviors for Brutus and Aurora were 60.9% and 66%, respectively. Because Inactive behaviors were low in frequency (for the 12 observations of Aurora and Brutus where reliability was measured, only 145 out of 5760 possible intervals recorded an Inactive behavior; approximately 2.5% of the intervals), the discrepancy in observer agreement was not considered important.

SigmaStat 3.1® was used for all statistical analyses. Except for differences between morning and afternoon observations and between walruses (which compared classes based on the entire hour of observation), the data for the classes of behaviors observed were split into ½ hr bins (0-30 min, 31-60 min), and both ½ hr bins and subjects were analyzed separately. Statistical analyses were conducted on the number of days for each condition representing individual observations (N) (see Experiment 1 Methods for this rationale). Differences between morning and afternoon observations were analyzed using standard t-tests. Differences between the walruses' baseline level of activity were analyzed using a standard repeated-measures ANOVA with subject as the blocking variable. When significant differences ($p < .05$) for the ANOVA's were found, post-hoc

pairwise comparisons (using Student Newman-Keuls test) were used to examine which of the three subjects significantly differed. For examinations of differences between the four conditions, planned t-tests were done for the following conditions: BL – M, BL – MF, BL – F, and MF – F. For all the comparisons noted above, when the data did not pass normality and/or homogeneity of variance, the data were analyzed using a Mann-Whitney U-test.

<p align="center">*Results/Discussion*</p>

Morning vs. Afternoon Activity

Figure 12 shows the mean percentage of occurrence between morning Baseline (BL) sessions (8 days) and all afternoon sessions (11 days) for all five classes of behavior (Active, Social, Inactive, Stereotypy and Other) across all four conditions (BL, M, MF, and F). No significant differences were found between morning and afternoon classes of behavior (all t-values were < 2.11). The only difference that approached significance was Brutus' Active behaviors, $t(17) = \pm1.946$, $p = .068$ (two-tailed), $d = .337$. These observations suggest that the walruses showed stable classes of behavior throughout their daily time on exhibit. Unlike other large carnivorous animals, walruses likely spend a considerable amount of their waking time foraging along the ocean floor. As a result walruses in the wild typically feed (and are fed in zoos) several times across the day.

Differences Among Walruses

A repeated-measures ANOVA with subjects as the blocking variable was performed comparing differences in classes of behaviors across the three walruses' morning Baseline (BL) observations. Active behaviors showed significant differences among walruses ($F_{2,21} = 25.74$, $p < .001$), $d = 1.00$. Nereus (the juvenile) spent more time

in Active behaviors compared to Brutus ($p < .001$) and Aurora ($p < .001$). Stereotypies also showed significant differences among walruses ($F_{2,21} = 30.160$, $p < .001$), $d = 1.000$. Nereus spent less time in Stereotypies compared with Brutus ($p < .001$) and Aurora ($p < .001$). Finally, Other behaviors showed differences among walruses ($F_{2,21} = 28.908$, $p < .001$), $d = 1.000$, with Nereus spending more time in Other behaviors than did Brutus ($p < .001$) or Aurora ($p < .001$). These differences were related to Nereus's significantly greater activity. Because he spent more time unpredictably moving about the exhibit, he was also more difficult to track and more likely to move into areas unobservable, resulting in an "Out of Sight" marking.

Other researchers have observed similar differences in the stereotypic activity of captive animals, with younger animals showing fewer examples of stereotypic activity than older animals (Mason, 1993; Montaudouin & Le Pape, 2004, Schoenecker, Heller, & Freimanis, 2000). Researchers have suggested that this difference is due to the greater length of captivity for the older animals (Cooper & Ödberg, 1991; Mason, 1993). A possible alternative explanation is that pre-pubescent and pubescent animals differ in foraging experience and motivation. In the younger animals, the motivation for more random play is stronger (Fagen, 1981; Loizos, 1966), producing fewer fixed stereotypic activities, since they would likely be engaged in less directed foraging/hunting activities. The requirements for food are larger in adults, and the motivation for foraging should also be stronger, while the role of play in adult behavior may be less.

Mat Contact

Figure 13 represents the mean percentage occurrence for Mat Contact across the Mat Alone (M) and Mat with Food (MF) conditions. The top graph shows the first ½ hr

after the mat was introduced, and the bottom graph shows the second ½ hr. During the

first ½ hr, all three walruses contacted the mat during the MF condition significantly

more than in the M condition (for Brutus, $U = 47$, $df = 14$, $p = .028$; for Aurora, $t(14) =$

± 4.628, $p < .001$ (two-tailed), $d = .992$; for Nereus, $U = 44.5$, $df = 14$, $p = .01$). There

were no significant differences during the second ½ hr between the two conditions for

any of the three walruses. In short, all 3 walruses paid little attention to the mats without

food in them, regardless of whether they once had food in them. However, when food

was present in the mat, all 3 walruses increased their contact.

These results show that the mats served as an appropriate substrate for delivering

food in the water. It should also be noted that although Brutus showed the fewest contacts

with the mat when food was present, there were systematic difficulties in observing his

contacts. First, he appeared to spend much of his time pulling food out of the mat from

underneath, where we could not see Mat Contacts. Second, his large size obstructed

visual confirmation of vibrissae-face contact with the mat when he was on top of a mat.

Further research would be improved by the use of multiple web cams aimed at exhibited

animals from different angles.

Baseline vs. Mat Alone

Both Figures 14 and Figure 15 display the mean percentage of occurrence for the

first ½ hr (Figure 14) and second ½ hr (Figure 15) of observation for all five classes of

behavior (Active, Social, Inactive, Stereotypy, and Other) across all four conditions

(Baseline, Mat Alone, Mat with Food, and Food Alone). For both Figures, the top graph

represents Brutus' results, the middle graph Aurora's results, and the bottom graph

Nereus' results. The only differences between the Mat Alone (M) condition to Baseline

(BL) were for Nereus' Inactive behaviors, which increased significantly during the first ½ hr ($U = 46$, $df = 14$, $p = .021$), and an increase that approached significance for the same comparison in the second ½ hr ($U = 51.5$, $df = 14$, $p = .083$).

The increase in Inactive behaviors for Nereus during the M condition compared to BL is likely a result of the novel introduction of the mat. The initial M condition marked the first time the mats were introduced in any form to the walruses, and during the first ½ hr of the initial M condition (first 4 trials the mat was introduced), Nereus engaged in a greater amount of Resting ($M = 22.29$, $SE = 1.29$) compared to his Resting during the second M condition, which were the final four trials the mat was presented ($M = 5.21$, $SE = 1.11$).

The increase in Resting during the initial introduction of the mat may have been fear-based (each mat was longer and wider than Nereus), since Nereus was noted during this time to maintain several meters distance from the mats without moving, and with his attention fixed in the direction of the mats. Also, the Resting response greatly decreased once food was introduced in the mats; all the walruses immediately approached the mats to consume the food. Therefore, Nereus appeared to increase Resting only when the adults did not approach the mats, as well as when no food was present upon the initial introduction of the mats.

No other significant differences were found for comparisons of the Mat Alone (M) and Baseline conditions. This, along with the limited Mat Contact during the M condition, suggests that although the mat may have been an effective means of providing food in an enriching way (see later results), the mat alone had no inherent ability to engage foraging behaviors in walruses.

Behavioral Classes: First ½ Hour

As noted previously, Figure 14 displays the mean percentage of occurrence for the first ½ hr for all five classes of behavior across all four conditions. The top graph represents Brutus' results, the middle graph Aurora's results, and the bottom graph Nereus' results.

Brutus

For Brutus, there were significant differences in Active behaviors. Active behaviors significantly increased from Baseline (BL) during the Mat with Food (MF) condition ($U = 42$, $df = 14$, $p = .005$) and during the Food Alone (F) condition ($U = 47$, $df = 14$, $p = .028$). The difference between MF and F was not significant, although the increase in Active behaviors during the MF condition ($M = 32.8$, $SE = 7.0$) was higher than the increase in Active behaviors observed in the F condition ($M = 20.3$, $SE = 4.8$).

There was also a significant increase in Inactive behaviors for Brutus when comparing BL to the F condition ($U = 49.5$, $df = 14$, $p = .05$). It's not clear why Inactive behaviors would increase compared to Baseline during this condition, although it could be because the treatment effect for the F condition that was less effective than the MF condition in increasing Active behaviors and decreasing Stereotypies.

Finally, there were significant decreases in Stereotypies from BL to the MF condition ($U = 96$, $df = 14$, $p = .002$) and to the F condition ($U = 89.5$, $df = 14$, $p = .021$). Similar to the effects seen in Active behaviors, the MF condition was not significantly different from the F condition. However, the MF condition ($M = 61.8$, $SE = 9.8$) did produce a greater reduction in Stereotypies compared to the F condition ($M = 73.2$, $SE = 7.1$).

Both the Mat with Food (MF) and Food Alone (F) conditions increased Active behaviors and decreased Stereotypies compared to Baseline (BL). The MF condition was not significantly different from the F condition, but showed both greater increases in Active behaviors and greater decreases in Stereotypies. These results give support, with respect to Brutus, that the mats provided a substrate that increased natural foraging behavior when food was present.

Aurora

For Aurora, there were significant differences in Active behaviors, with increases from Baseline (BL) during the Mat with Food (MF) condition, $t(14) = \pm 2.166$, $p = .048$ (two-tailed), $d = .422$, and during the Food Alone (F) condition ($U = 47$, $df = 14$, $p = .028$). The difference between MF and F was not significant, although the increase in Active behaviors during the MF condition ($M = 51.3$, $SE = 8.6$) was lower than the increase observed during the F condition ($M = 57.9$, $SE = 9.2$).

There were significant increases in Social behaviors for Aurora from BL to the MF condition ($U = 44$, $df = 14$, $p = .01$) and to the F condition ($U = 44$, $df = 14$, $p = .01$). A significant increase in Other behaviors from F to the MF condition ($U = 89$, $df = 14$, $p = .028$) was also observed. The increase in Social behaviors during the two food conditions was a result of Aurora contacting Nereus more in the process of competing for and obtaining food. It is worth noting that these contacts did not appear to be aggressive in nature, but a result of foraging within close proximity of another walrus. The difference in Other behaviors observed is not clear, although it may have been a result of the mats partially obstructing the ability to observe Aurora while foraging during the MF condition.

Finally, Stereotypies decreased from BL to the MF condition, $t(14) = \pm2.492$, $p = .021$ (two-tailed), $d = .604$, and from BL to the F condition $t(14) = \pm2.776$, $p = .015$ (two-tailed), $d = .677$. Similar to the effects seen in Active behaviors, the MF condition was not significantly different from the F condition.

These results suggest that both the MF and F conditions were similar in their ability to increase Active and Social behaviors and decrease Stereotypies. However, results from the second ½ hr (Figure 14, see results below) show differences between the two food conditions in terms of their ability to maintain such effects.

Nereus

Unlike the two adult walruses, Nereus maintained a high level of Active behaviors and low level of Stereotypies during Baseline (BL), and showed no significant differences for these behaviors during the Mat with Food (MF) or Food Alone (F) conditions. There was a significant increase in Social behaviors from BL to the MF condition ($U = 42.5$, $df = 14$, $p = .005$). This matched Aurora's increase in social behaviors during this condition, and was a result of the two walruses contacting each other while competing for and obtaining food from the mats. Again, these contacts did not appear to be aggressive in nature.

Behavioral Classes: Second ½ Hour

As noted previously, Figure 15 shows the mean percentage of occurrence for the second ½ hr for all five classes of behavior across all four conditions. The top graph represents Brutus' results, the middle graph Aurora's results, and the bottom graph Nereus' results.

Brutus

Brutus showed no significant differences for any of the conditions during the second ½ hr. These results, along with the previous Mat Contact data, suggest that the enriching function of the Mat with Food (MF) and Food Alone (F) condition were short-lived for Brutus, presumably because most if not all of the food had already been consumed in the first ½ hr.

Aurora

Active behaviors significantly increased from Baseline (BL) during the Food Alone (F) condition ($U = 46.5$, $df = 14$, $p = .021$). The F condition also showed significantly greater Active behaviors when compared to the Mat with Food (MF) condition, $t(14) = \pm2.955$, $p < .01$ (two-tailed), $d = .743$. Aurora also significantly increased Social Behavior from BL to the Food condition ($U = 46$, $df = 14$, $p = .021$). Again, these increased Social behaviors resulted primarily from contacting Nereus while foraging near him, and did not appear aggressive.

Finally, Aurora significantly decreased Stereotypies from BL to the Food (F) condition, $t(14) = \pm3.791$, $p = .002$ (two-tailed), $d = .938$. Similar to the effects seen in Active behaviors, The F condition showed significantly fewer Stereotypies when compared to the Mat with Food (MF) condition, $t(14) = \pm2.591$, $p < .021$ (two-tailed), $d = .603$.

While the results in the first ½ hr showed that both the MF and F conditions were effective in increasing Active and Social behaviors while reducing Stereotypies, the results of the second ½ hr showed that only the effects of the F condition continued to be effective more than a ½ hr after their introduction. Therefore, for Aurora, introducing

food by itself was more effective as an enrichment strategy than introducing food within a foraging mat.

Nereus

Only one difference approached significance for Nereus; greater Active behaviors in the Food Alone (F) condition when compared to the Mat with Food (MF) condition, $t(14) = \pm1.886$, $p = .08$, $d = .307$. This increase appeared to result from Nereus following Aurora around the pool while she maintained her increase in Active behaviors over the second ½ hr of observations during this condition.

Behavioral Classes Conclusions

While both the Mat with Food (MF) and Food Alone (F) conditions appeared to have similar effects in increasing Active behaviors and reducing Stereotypies in the two adult walruses, there were differences that recommended alternative enrichment strategies for each walrus. For Brutus, while both conditions were effective at increasing Active behaviors and reducing Stereotypies, and no significant differences were found between the two treatments, the MF condition did show greater effects (in terms of differences of means) for both measures. In contrast, Aurora's effects observed in the second ½ hr (Figure 14) showed that the F condition was more effective than the MF condition at maintaining increased Active behaviors and decreased Stereotypies.

One possible reason for this difference between the adult walruses is that, while the MF condition maintained food in one particular area (predominantly on or around the mats), the F condition dispersed the same amount of food along the floor of the pool. Brutus and Aurora also displayed considerable differences in the type of stereotypic activity in which they typically engaged. Brutus spent 71% of his stereotypic activity

engaged in flipper sucking, whereas Aurora spent 91.9% of her stereotypic activity engaged in a form of circle swimming. As a result, restricting food to the mats (MF) may have been better suited to disrupt stereotypic activity for Brutus, who engaged mostly in stationary stereotypic activity. In contrast, scattering food across the bottom of the pool (F) may have been better suited for interfering with the circle swimming stereotypic activity shown by Aurora.

<div align="center">Experiment 6</div>

In Experiment 5, the two adult walruses primarily exhibited two different forms of stereotypic activity during an experimental session with food available: locomotor circle swimming for Aurora and stationary flipper sucking for Brutus. Circle swimming appears likely related to searching for and moving between feeding locations and individual prey, while flipper sucking is less clear. Recent observations of walrus foraging in the wild showed extensive use of their flippers in stirring up the sandy bottom apparently in searching for shell fish (Levermann, Galatius, Ehlme, Rysgaard, & Born, 2003), indicating that flipper manipulation of the substrate plays a large role in focal search. On the other hand use of the mouth in suctioning shell fish out of their shells is also an end component of focal search, so suctioning the flippers may be related to a behavior proximate to obtaining food.

The purpose of the sixth experiment was to provide the walrus with the opportunity to use its flippers more actively in our captive circumstances. All walruses were provided with a manipulable object containing food (large, hollow, plastic slotted "boomer- balls" with or without fish inside). The balls could be held stationary in the water by the walrus using its flippers, or it could be moved with the flippers and face

around the exhibit. In either case, I would expect interest in the balls to reduce both the circle swimming and flipper sucking observed in Experiment 5. Unlike the mats from Experiment 5, the boomer balls allowed the walruses to engage in their preferred form of foraging; stationary suctioning or locomotor search. I also expected the boomer balls without food, like the mats without food, to hold no intrinsic enriching function.

Methods

Subjects and Enclosures

The subjects and enclosure were the same as used during Experiment 5.

Materials

Two 61 cm diameter balls were used during morning observations. The balls, commonly referred to as "boomer balls", were made of a hollow, hard polyethylene plastic with 6 holes (5-4 cm diameter holes and 1-10 cm diameter hole) drilled through the surface. Both balls floated rather than sinking to the bottom, although they could be easily dragged underwater by a walrus. The balls were either introduced empty (Ball Alone condition) or stuffed with 15 capelin, 5 herring and 5 clams each (Ball with Food condition). All additional materials were the same as Experiment 5.

Data Collection and Procedures

The ethogram was the same as used during Experiment 5. Observations were conducted from November 2005 through April 2006. A total of 8 researchers were involved in the total data collection. Data were taken two times per week, Saturday and Sunday, throughout the study. Only morning sessions were observed to keep the present experiment within the same circadian time frame as Experiment 5 (1030 to 1200 hr). Observation length, method, place of occurrence, and foraging device introduction were

the same as Experiment 5. As with Experiment 5, a within-subject reversal design (order described below) was used, but only for the two following conditions:

Ball Alone (B) – Two 61 cm diameter Plastic balls were introduced at the beginning of each observation.

Ball with Food (BF) – Both balls introduced with 15 capelin, 5 herring, and 5 clams each (50 food items total) placed inside the balls.

Because the mat alone and baseline conditions showed little difference in Experiment 5, and after observing that the Ball Alone (B) condition showed a similar trend, I focused on the B and BF conditions for Experiment 6. The, sessions were semi-randomized between B and BF conditions (1 – 5 sessions per condition) to test for both habituation (reduced responding due to familiarly with the boomer balls) and carryover effects (continued responding to a boomer ball without food because of its previous containment of food). A total of 28 sessions were observed, 10 B, and 18 BF conditions. The reversals were run in the following order (with # of sessions in parentheses): BF(2)B(1)BF(5)B(2)BF(4)B(2)BF(2)B(2)BF(2)B(1)BF(2)B(2)BF(1)

Interobserver agreement (IOA) was calculated based on total agreement (Poling, Methot, & LeSage, 1995) for 21.4% of all sessions conducted. This produced a percentage of agreement for each of the classes of behaviors observed and for each walrus. All measures of total agreement were above 80%, with two exceptions. IOA for Other behaviors for Brutus and Aurora were 44.4% and 50%, respectively. Because Other behaviors were low in frequency (for the 7 observations of Aurora and Brutus where reliability was measured, only 29 out of 1440 possible intervals recorded an Other

behavior), the discrepancy in observer agreement for Other behaviors during Experiment 6 was not considered important.

SigmaStat 3.1® was used for all statistical analyses. All data were split into ½ hr bins (0-30 min, 31-60 min), and both ½ hr bins and subjects were analyzed separately. For examinations of differences between the two conditions, standard t-tests were used. In addition, t-tests were used to compare the BF to either the MF or F condition from Experiment 5, and Ball Contact with Mat Contact from Experiment 5. When the data did not pass normality and/or homogeneity of variance, the data were analyzed using a Mann-Whitney U-test.

To examine potential habituation effects, line plots of Ball Contact percentages during their first ½ hr of introduction were plotted for all 18 days the Ball with Food (BF) condition was implemented.

<div align="center">Results/Discussion</div>

Ball Contact

Figure 16 shows the mean percentage of occurrence for Ball Contact across the Ball (B) and Ball with Food (BF) conditions. The top graph shows the first ½ hr after the boomer balls were introduced, and the bottom graph shows the second ½ hr of the boomer balls' presence. During the first ½ hr, all three walruses significantly increased their Ball Contact during the BF condition compared to the B condition (for Brutus, $U = 61$, $df = 26$, $p < .001$; for Aurora, $U = 55$, $df = 26$, $p < .001$; for Nereus, $U = 58$, $df = 26$, $p < .001$). During the second ½ hr, only Aurora continued to significantly contact the boomer balls more during the BF condition than the B condition ($U = 90.5$, $df = 26$, $p = .01$). While Brutus and Nereus still contacted the boomer balls in the second ½ hr, the

contact did not differ significantly between the B and BF conditions. As with the mats in

Experiment 5, all 3 walruses paid little attention to the boomer balls without food in

them, and only one of the walruses (Aurora) contacted the boomer balls more than

incidentally after the first ½ hr of their introduction.

Within the first ½ hr, all 3 walruses showed significantly greater contact

comparing the Ball with Food (BF) to the Mat with Food (MF) conditions (for Brutus, U

$= 40.5$, $df = 24$, $p < .001$; for Aurora, $U = 36$, $df = 24$, $p < .001$; for Nereus, $U = 68$, $df =$

24, $p = .028$). Also, Aurora continued to contact the boomer balls during the BF condition

significantly more than the B condition in the second ½ hr, which had not been the case

with the mats. These results indicate that the boomer balls functioned better as potential

food-containing enrichment items for the walruses than the mats (as shown by significant

differences and percentage of contact), and thus were functionally more appropriate for

eliciting foraging behavior in the walruses.

Behavioral Classes: First ½ Hour

Figure 17 displays the mean percentage of occurrence for the first ½ hr for all five

classes of behavior (Active, Social, Inactive, Stereotypy, and Other) across both

conditions (Ball Alone and Ball with Food). The top graph represents Brutus' results, the

middle graph Aurora's results, and the bottom graph Nereus' results.

Brutus, BF vs. B

There was a significant increase in Active behaviors when comparing the Ball

with Food (BF) condition to the Ball Alone (B) condition ($U = 71$, $df = 26$, $p < .001$), as

well as an increase that approached significance in Social behaviors when comparing the

same conditions ($U = 106.5$, $df = 26$, $p = .068$). Stereotypies significantly decreased when

comparing the BF condition to the B condition, $t(26)= \pm 5.241$, $p < .001$ (two-tailed), $d =$ 1.0. These results suggest that the BF condition was an effective enrichment tool for Brutus during the first ½ hour of its introduction.

Brutus, BF vs. MF

The Mat with Food (MF) condition from Experiment 5 appeared to be the most successful condition for Brutus in terms of increasing Active behaviors and decreasing Stereotypies. As a result, I compared the MF condition with the Ball with Food (BF) condition to see if there was a significant difference between the two conditions. The BF condition was significantly better at increasing Active behaviors, $t(24) = \pm 2.113$, $p = .045$ (two-tailed), $d = .419$, and decreasing Stereotypies, $t(24) = \pm 3.2$, $p = .004$ (two-tailed), $d = .845$, when compared to the MF condition. Therefore, for Brutus, the boomer balls with food appeared to be a more effective way of increasing Active behaviors and reducing Stereotypies compared to the mats with food during the first ½ hr of their introduction.

Aurora, BF vs. B

There was a significant increase in Active behaviors when comparing the Ball with Food (BF) condition to the Ball Alone (B) condition ($U = 68$, $df = 26$, $p < .001$). Stereotypies significantly decreased when comparing the BF condition to the B condition, $t(26) = \pm 5.580$, $p < .001$ (two-tailed), $d = 1.0$. These results suggest that the BF condition was an effective enrichment tool for Aurora during the first ½ hr of its introduction.

Aurora, BF vs. F

The Food Alone (F) condition from Experiment 5 appeared to be the most successful condition for Aurora in terms of increasing Active behaviors and decreasing Stereotypies. However, a comparison of the F condition with the Ball with Food (BF)

condition showed no significant differences during the first ½ of observation for two conditions. Therefore, for Aurora, the boomer balls with food were equally as effective at increasing Active behaviors and decreasing Stereotypies as the F condition during the first ½ hr after their introduction.

Nereus, BF vs. B

The Ball with Food (BF) condition compared to the Ball Alone (B) condition showed a significant increase in Social Behaviors ($U = 103$, $df = 26$, $p = .046$), and a significant decrease in Stereotypies ($U = 189.5$, $df = 26$, $p = .035$). In both Experiments 5 and 6, Nereus maintained a high level of Active behaviors and low level of Stereotypies during non-food conditions. Unlike the Mat with Food (MF) and Food Alone (F) conditions for Nereus, the BF condition was able to reduce Stereotypies even further than Baseline during the first ½ hr of its introduction.

Nereus, BF vs. MF, BF vs. F

For Nereus, neither the Mat with Food (MF) or Food Alone (F) conditions from Experiment 5 increased Active Behaviors or decrease Stereotypies when compared to Baseline. As a result, I compared both MF and F conditions with the Ball with Food (BF) condition to see if there was a significant difference for BF between the MF or F conditions. No significant differences were observed for the first ½ of observation between the BF and MF conditions. However, the BF condition showed an increase in Active behaviors that approached significance when compared to the F condition, $t(24) = \pm1.901$, $p = .069$ (two-tailed), $d = .327$. Also, the BF condition showed a significant decrease in Stereotypies when compared to the F condition ($U = 148$, $df = 24$, $p = .028$).

The BF condition, therefore, appeared to be better in terms of increased Active behaviors and decreased Stereotypies for Nereus when compared to Food Alone in the first ½ hr.

Behavioral Classes: Second ½ Hour; Aurora and BF vs. F

Figure 18 displays the mean percentage of occurrence for the second ½ hr for all five classes of behavior across both conditions. The top graph represents Brutus' results, the middle graph Aurora's results, and the bottom graph Nereus' results.

The only significant differences observed when comparing the Ball with Food (BF) condition to the Ball Alone (B) condition were an increase in Aurora's Active behaviors ($U = 99.5$, $df = 26$, $p = .031$) and a decrease in Stereotypies, $t(26) = \pm3.192$, $p = .004$ (two-tailed), $d = .846$. Likewise, only Aurora showed a significant difference in comparisons between either the BF and Mat with Food (MF) or Food Alone (F) conditions in the second ½ hr; the BF condition showed a significant decrease in Active behaviors when compared to the F condition, $t(24) = 2.211$, $p = .037$, $d = .463$. Therefore, for Aurora, particularly in the second ½ hr, the boomer balls with food appeared to be a less effective way of increasing Active behaviors compared to the Food Alone condition.

Ball Contact across BF Sessions

Figure 19 shows the percentage of Ball Contact per session (18 total sessions) during the first ½ hr of the Ball with Food (BF) condition.

Aurora and Nereus

For both Aurora and Nereus, rapid habituation was observed, with the first 2 sessions representing the highest percentage of contact (Aurora, 55 and 65.8%; Nereus, 42.5 and 30.7%, respectively) and steadily decreasing to 14.5% during session 10 for Aurora, and 3.3% during session 8 for Nereus. However, following these sessions, both

walruses continued to show spikes in Ball Contact for the rest of the BF sessions, and neither showed a continued decline in Ball Contact that dropped below their session 10 (for Aurora) and 8 (for Nereus) percentage of occurrence.

Brutus

In contrast, Brutus showed an initial reluctance to contact the boomer balls, but gradually increased Ball Contact across the first several sessions, and after session 9, showed interspersed spikes in Ball Contact activity for the remainder of the sessions. Following session 15 (the session with his highest percentage of contact; 51.7%), he continued to show a level of Ball Contact activity similar to that observed during his first several sessions. Together, Figure 19 shows that, while for 2 of the 3 walruses, there was rapid habituation, all walruses continued to show considerable interest in the boomer balls with food during the first ½ hr following their introduction. This suggests that food-based enrichment should continue to maintain interest, as long as food continues to be available. Rather than an animal becoming habituated to an item that previously alleviated "boredom", enrichment should continue to maintain foraging activity while it gives an animal a reason to forage. In other words, animals may discover ways of extracting food faster, but a foraging-motivated animal should not lose interest in devices that adequately and continuously present consumable items on a regular basis.

<center>General Discussion, Walruses</center>

Stereotypic Activity Throughout the Day

As reported in Experiment 5, all three walruses appeared to show a stable level of responding across all five classes when comparing morning and afternoon sessions. This suggests that the adult walruses maintained a more or less high, unchanging level of

stereotypic activity throughout their time on exhibit. Other researchers have observed this not to be the case with other large captive carnivores with different prey habits, such as polar bears and ocelots, where stereotypic activity and activity in general typically increase in the hours before their single daily feed, as reported here, but also sometimes fluctuates apparently randomly throughout the day (Wechsler, 1991; Weller & Bennett, 2001).

Two possible reasons for the different distributions of stereotypic activity and other classes of behavior in the walruses are: (1) they were fed 3-5 times a day, unlike the more standard once a day feed for captive carnivores, as was the case for the polar bears, and (2) walruses are an atypical large predator, in the sense that they spend most of the day consuming small prey frequently, rather than capturing large prey once a day, or only every several days.

Stereotypies as a Function of Multiple Feedings

If the several feedings a day were partially responsible for this stable responding, one might expect a lower incidence of stereotypic activity, as other researchers have demonstrated in carnivores is an effective treatment for reducing stereotypic activity compared to the once a day feed (Shepherdson, Carlstead, Mellen, & Seidensticker, 1993). However, the two adult walruses still engaged in large amounts of stereotypic activity, 80+% of their total possible behaviors during baseline conditions.

It's possible that multiple feedings only produce temporary relief from stereotypic activity, or that hiding of the food or unpredictable time deliveries (as opposed to the food delivered during training sessions at predictable times) are necessary. Alternatively, the key differences with other large carnivores may be that walruses have evolved to

maintain a high level of foraging across the whole day, producing relatively constant foraging in the zoo setting and similar levels of foraging and activity in the wild.

It is worth noting that feeding several times a day as opposed to once a day may also be beneficial for the welfare of walruses in general, especially considering that the several times a day feedings are more representative of how they would consume food in the wild. In terms of their use as a treatment to reduce stereotypic activity, however, based on the results with our walruses, who maintained high levels of stereotypic activity throughout the course of multiple feedings, I would predict that a strategy of several feeds a day would have little impact on stereotypic activity in captive walruses.

The key to stereotypic activity for our adults was the extent to which the food elicited constant focal search behaviors and consumption through the use of many small amounts of food. This can be achieved by the use of items or feeding tactics that require the walrus to consume large amounts of food in small individual amounts over long periods of time. Additionally, since flipper manipulation is now known to be an important component of walrus foraging, food-related items that allow use of the flippers will likely be better suited for maintaining a low level of stereotypic activity.

Young vs. Adult Stereotypies

Nereus engaged in considerably less Stereotypies and more Active and Other behaviors compared to the two adult walruses. As previously noted, some researchers have suggested that less stereotypic activity in young animals is due to the shorter amount of time the animal has spent in captivity. These researchers argue that stereotypic activity initially becomes established within particular contexts, and then eventually becomes emancipated from their original causes, presumably because they have occurred within

that context for a lengthy period of time (Mason, 1993). While the mechanisms for how this would occur have not been described, one possibility is that some form of conditioning to contextual stimuli allows those stimuli to elicit or set the occasion for stereotypic activity, even in the absence of initially eliciting or occasion setting events such as hunger or mate seeking. This would be similar to lab animals undergoing respondent or operant procedures learning to associate responses with the experimental chamber setting (contextual stimuli) or to particular stimuli in the experimental chamber, such as a light (conditional/discriminative stimulus).

An alternative explanation for our findings is that Nereus engaged in significantly less stereotypic activity compared to the two adult walruses because, as a juvenile walrus, the drive to forage is less (smaller size and parental care might minimize foraging needs), while other activities such as play were likely motivated as well. This hypothesis makes the same predictions in this case as the establishment/emancipation explanation of stereotypic activity, where pre-pubescent animals (those with little captive experience) engage in less stereotypic activity. However, these two hypotheses should make different predictions in the case of: (1) wild-caught adults compared to captive-bred adults, and (2) younger adults compared to older adults.

According to the establishment/emancipation hypothesis, captive-bred adults should engage in significantly greater stereotypic activity than wild-caught adults, as should older compared to younger adults. The foraging/play hypothesis, however, would suggest that, after the novelty of an exhibit and/or captive experience diminished, little difference between both these groups of adults should exist. To date, the research on the effect of age/history of captivity on stereotypic activity has either been inconclusive, or

has compared pre-pubescent animals to adults (Mason, 1993; Mountaudouin & Le Pape, 2004; Schoenecker, Heller, & Freimanis, 2000).

Focal Search and Focal Swimming

As noted in the chapter introduction, many of the behaviors exhibited while swimming still appeared to resemble focal search behaviors. For instance, both while swimming stereotypically and non-stereotypically, we coded swim patterns that contained contact of a pool surface by the face/vibrissae. One of the two stereotyped swim patterns and one of the two non-stereotyped swim behaviors involved a foraging-like contact made to some surface in the pool. Swimming with pool surface contact accounted for 33.1% of all swim behaviors during Experiment 5. In addition, contacts occurred to the bottom of the pool, but were difficult to observe, and therefore unverifiable. Also, contacting the surface of the water with face/vibrissae while swimming on their backs was not coded as a swim with contact behavior, even though it occurred quite frequently. Therefore, the percentage of swim behaviors that incorporated a focal search-like face/vibrissae contact to some area was likely higher than the 33.1% reported above (~75% of each loop of Circle Swimming appeared to involve some type of face/vibrissae contact to a surface that was either water surface [and thus not coded as contact to a "surface"] or unverifiable).

Experiment 6 attempted to account for the high percentage of focal search swim behaviors by providing a foraging device (the boomer balls) that the walruses could contact with their face/vibrissae while swimming. While the mats did allow face/vibrissae contacts that are necessary for walrus foraging sequences, they did not allow a walrus to travel while engaged in focal face/vibrissae contacts. The boomer balls did allow such

behaviors, and while Brutus was observed to remain stationary and manipulate/spin the boomer balls with his flippers, Aurora and Nereus were observed to push the boomer balls with their face and flippers around the exhibit, and therefore, spent a considerable amount of time traveling while contacting the boomer balls.

Mats vs. Boomer Balls

For all the walruses the boomer balls used in Experiment 6 appeared to be more effective than the mat as an enrichment device eliciting contact. They were also more effective at reducing stereotypic activity and increasing general activity for Brutus during the first ½ hr after their introductions. Indirect evidence suggested that this was also the case for Nereus, who showed a reduction in stereotypic activity in the first ½ when comparing the Ball with Food (BF) to the Ball Alone (B), but the Mat with Food (MF) was not significantly different than the Mat Alone (M) or baseline. For Aurora, only one difference was observed when comparing the BF condition to her most effective condition in Experiment 1, the Food Alone (F) condition. During the second ½ hr, the F condition appeared to be more effective at maintaining increases in Active behaviors than the BF condition.

Initially, the mats were selected as a foraging device because of their thick texture and size, thus providing a potential substrate functionally similar to the ocean floor for the walruses to forage on. However, after obtaining the results of Experiment 5 and the more recent discovery of the use of flippers for foraging by walruses in the wild, I implemented the boomer ball experiment. The boomer balls as foraging devices allowed each walrus to use extensive flipper manipulations to obtain food from the devices, as well as use them in either a stationary or movable manner.

Treatment Effect and Form of Stereotypic Activity

As noted in Experiment 5, there were considerable differences in what treatments were effective for each walrus, particularly between the two adult walruses, and these differences were once again observed in Experiment 6. One explanation is that the form of the stereotypic activity the two adult walruses displayed dictated what type of foraging activity they were more likely to engage in, and therefore what type of treatment would be more effective. For Aurora, who engaged predominantly in locomotion-based stereotypic activity, the F condition was more effective than the MF condition, since the Food Alone condition was more likely to spread the food across the exhibit.

While the BF condition elicited significantly greater contact than the MF condition did, and while Aurora was often observed to push the ball around the exhibit, which still allowed her to engage in a locomotion-based foraging activity, it was still not as effective as Food Alone, at least not in the second ½ hr with respect to maintained Active behaviors. Brutus, however, engaged predominantly in flipper sucking, a stationary stereotypy, and showed greater increases in Active behaviors and greater decreases in Stereotypies during the MF condition. In addition, during the first ½ hr, the BF condition was more successful at eliciting contact, increasing Active behaviors, and reducing Stereotypies when compared to the MF condition for Brutus. Brutus, in comparison to Aurora, was often observed to grip one of the boomer balls between his flippers and slowly rotate the ball while periodically sucking on the holes.

Exhibit/Enrichment History

Aurora, as noted in Experiment 5 and 6, was the only walrus to show significant effects that lasted beyond the first ½ hr. In addition, while less effective than the Food

Alone treatment, Aurora showed the highest level of contact to both the mats and boomer balls, and was the only walrus that maintained significantly greater contact with the boomer balls into the second ½ hr after their introduction. One possible reason for this was that Aurora spent almost her entire life at the Indianapolis Zoo, where she received enrichment and training several times a day throughout most of her life. Brutus, as noted previously in the walrus Introduction, was maintained in a smaller pool for much of his captive life, where he was reported to receive less training and enrichment. In addition, Brutus was specifically rewarded for sucking on his flipper rather than damaging parts of his pool prior to arriving at the Indianapolis Zoo.

These two variables combined may explain why Brutus both engaged in flipper sucking for the predominant percentage of his stereotypic activity, and why searching for food outside of enrichment items, as well as the lasting effects of enrichment, were less compared to Aurora. While the walruses' environmental histories may help explain the topography of the stereotypic activity exhibited, the underlying motivation to forage still resulted in (1) a similar level of stereotypic activity, regardless of the form, for both adult walruses, and (2) our ability to manipulate the stereotypic activity with the use of food and food-related stimuli.

Stereotypic Activity and Foraging

Overall, both experiments supported the hypothesis that the walruses' stereotypic activity would be related to species-specific foraging activities, and that the use of naturally occurring stimuli, such as food and items containing food that allow for species-specific foraging activities, are ideal for deterring stereotypic activity and increasing species-specific, "naturalistic" behaviors in captive settings. While these manipulations

were experimental designs intended to examine the relationship of such stimuli to foraging activity (and therefore only examined a fraction of the effects on overall daily activity), they provide some insight into the long-term goal of deterring stereotypic activity and other aberrant behaviors throughout the life of a captive animal. Future work could focus on the long-term effects of such devices, as well as the development of additional species-specific foraging devices making better contact with species typical sensory and motor capabilities and tendencies.

The key to a foraging device that reduces stereotypic activity is the fit between the device and the set of behaviors the animal uses in captive foraging. Stereotypic activity can be viewed as an animal's way of telling you what kinds of behaviors and sensory motor mechanisms are available in those circumstances, and therefore, how that animal will interact with its exhibit and the items introduced into their enclosure. Viewed in this way, stereotypic activity is a source of information about the animals foraging tendencies and abilities. Discovering how to engage those mechanisms and behaviors appears important in both increasing species-specific foraging repertoires and reducing stereotypic activity. Thus we can at the same time improve the welfare of the animals, educate the observers, and help form a better model of how that animal functions in its ecological niche.

GENERAL DISCUSSION

As evidenced by Experiments 1-4, the locomotor stereotypic activity of polar bears is a function of the motivation to forage, and therefore part of the foraging system that polar bears evolved in the wild. These niche-related stereotypies, while appearing and often diagnosed as "abnormal", are a direct result of the need to forage, and are

modified by events that occur within their captive environment, such as the how and when they are fed.

Polar Bears and When Food is Delivered

By examining the responses of polar bears to several schedules of food deliveries (i.e., the Fixed- and Variable-Time schedules), we were able to demonstrate that polar bears (a) will decrease stereotypic activity, increase non-stereotypic activity, and increase overall enclosure use in the times prior to and during most food schedules, (b) will not modify their behaviors prior to a food schedule when that schedule is not predictable (i.e., Variable-Time schedules), (c) do not show the level of decreased stereotypic activity and increased non-stereotypic activity to the same amount of food delivered at one time, thus demonstrating the importance of food schedules "releasing" stereotypic foraging loops as a result of presenting reoccurring consumable focal stimuli, and (d) need to contact and/or consume focal stimuli in order to disrupt stereotypic activity. Taken together, these results suggest that locomotor stereotypic activity in polar bears and similar large carnivores result from general search behaviors that do not receive focal stimuli to move their foraging into focal search and consumption, thus causing repeated general search actions (i.e., foraging loops) that increase in frequency and strength as the motivation to forage increases. This also explains why, for many carnivores, stereotypic activity would be most pervasive at times just prior to a large daily feed.

Walruses and How Food is Delivered

Similarly, Experiment 5-6 demonstrated that the stereotypic activity of walruses was able to be disrupted by providing methods of food deliveries that allowed the walruses to search for and locate food over extended periods of time. Two of these

methods involved using an ocean floor-like substrate (Experiment 5's large mats) and a puzzle-feeder-like device (Experiment 6's boomer balls) that encouraged flipper and vibrissae/mouth manipulations to obtain the food. The third method involved dumping food in such a way that it encouraged locomotor search throughout the exhibit to discover "hidden" food along the bottom of the pool (Experiment 5's Food Alone condition).

The key to disrupting walrus stereotypic activity was providing methods that increased the amount of time it took a walrus to consume food, as well as the simple act of allowing walruses to engage in consumption. Walruses, unlike polar bears, spend a considerable amount of their day searching for and consuming mollusks, and thus spend the majority of their captive time searching for any substrate they can engage in similar foraging behaviors with. These behaviors emerge as locomotor stereotypic activity with mouth/vibrissae contact to different pool surfaces, as well as stereotypic flipper sucking. These behaviors also appear to remain stable across the day, rather than increasing towards a large daily feed. This is because the motivation to forage in walruses should remain relatively stable throughout their waking time, since foraging on small prey items in the wild requires eating a large quantity of individual prey to support their large size.

Contrasting and Comparing Polar Bears and Walruses

As noted previously, polar bears and walruses, while both large carnivores, show considerably different foraging behaviors in the wild. Polar bears engage in an extreme form of carnivore predating, where they travel long distances in the wild in search of infrequent large meals. Polar bears are known to go weeks, even months, without capturing and thus consuming any prey (Stirling, 1988). Much of that time may still involve traveling large distances in an attempt to locate prey.

In contrast, walruses are an atypical carnivore that "grazes" to consume its prey, much like many ungulates graze upon vegetation in the wild. As a result, they spend a considerable amount of their time contacting and consuming mollusks, and any travel required is a result of traveling to new beds of mollusks and while searching across the ocean floor for new mollusks. This type of predating requires considerably less time traveling and considerably more time contacting, manipulating, and consuming prey than they average carnivore, particularly polar bears.

Similar Strategies for Contrasting Functions

Because of these largely contrasting foraging styles, one might ask, "why, then, would similar strategies of allowing polar bears and walruses to consume small amounts of food over long periods of time work equally well at disrupting supposed species-specific, foraging-based stereotypic activity in both species?" The answer is most easily explained by revisiting Figure 1. In this diagram of the typical foraging behavior of wild and captive carnivores, we can see that your typical carnivore, like a polar bear, remains in a foraging loop because it does not receive the necessary focal stimuli needed to push that animal into focal search and then food contact and consumption. As a result, small amounts of consumable food items push the polar bears out of their general search loops, and hence why stereotypic activity decreases and non-stereotypic search behaviors increase. Interestingly, because polar bears are such an extreme case of the typical carnivore, traveling incredibly long distances in search of food, and because they have advanced olfactory capabilities, they likely identify focal stimuli in the form of prey scents from long distances away from that potential prey. Therefore, a considerable

amount of their focal search behavior likely involves locomotion in the form of directed traveling towards that prey scent.

Walruses in the wild, however, should spend a relatively small proportion of their total foraging time in general search behaviors of looking for mollusks, because of the tendency of shellfish to occur in high densities where the conditions of wave actions and nutrients are conducive to survival and reproduction. It would follow that, the majority of walrus foraging activity in the wild should involve the focal behavior of stirring up mollusk beds, using their vibrissae to locate them, jets of water and their flippers to remove overlying sand, brining them into the mouth using lips, teeth, and tongue, and then using suction applied to the mollusk shell to remove and consume it.

Based on these data about foraging, it appears reasonable to expect much of the stereotypic activity occurring in captive walruses to be a function of consuming much of their food quickly (as delivered "by hand"), providing cues that allow the animal to begin a foraging bout, but with less than complete expression of the foraging behaviors engaged in discovering mollusks on the ocean floor, including travel to the beds, but particularly use of the flippers, whiskers, water jetting and extraction suctioning. Therefore, in their stereotypies, walruses might be expected to show loops of focal search, including loop swimming with contact of the walls, floor, and water surface of the pool with the vibrissae and mouth, and flipper sucking.

One solution in the case of both the polar bear and the walruses is to provide frequent access to small food items in ways that engage aspects of foraging. In the case of the polar bear, providing small amounts of food during the day on several Fixed- and Variable-Time schedules appeared to interrupt and reduce locomotor search stereotypies

in favor of more focal search, and included the increased and more equal use of the

multiple areas in the enclosure. The food items first function as focal stimuli that are

found and consumed by the polar bear, thus disrupting its locomotor search stereotypies.

. For walruses, food, especially food that is delivered in ways that allowed flipper

manipulation and use of the vibrissae, appeared to disrupt flipper sucking and circle

swimming.

A Simple Conclusion Elaborated

While the effects may seem simple to explain—of course, food interrupts other

behaviors, the animals start eating—two aspects of the effects are important to focus on.

The first is that small amounts of food (and food in general) do not always disrupt

stereotypic activity. In fact, particularly when presented in a predictable fashion, they

may actually elicit stereotypic activity and/or other behaviors that work to the detriment

of an animal's welfare. Such is the case with the previously discussed laboratory rat

example, where periodic deliveries of food increase excessive water drinking (i.e.,

polydipsia), which occurs at high enough levels to be stressful for the rat. Also,

presenting high calorie food to ungulates and pigs frequently produces post-food

mouthing and biting stereotypies following a large daily feed (Lawrence & Terlouw,

1993). In this case, the food appears to elicit stereotypic activity because the ungulate diet

is a high-caloric, processed meal, and thus is consumed far more quickly and with

considerably less food manipulation than would be required from such behavior in the

wild. As a result, following food consumption, the ungulate remains motivated to engage

in extended consumption behaviors, including mouthing, licking, and biting objects

repeatedly. The solution in this case appears to be decreasing the calorie density of the

food, and create the circumstances for more "handling" behavior to get at the nutrients. Delivering small amount of high calorie food at relatively large intervals might actually exacerbate ungulate stereotypic activity as the animal continued to engage in mouthing behaviors between each portion of its daily ration.

The delivery of intermittent small amounts of food seems better suited to dealing with carnivores, although it seems that the intermittency might have different effects in animals evolved to gather small amounts of food vs. large amounts of food. In trying to use food consumption as a way to examined the causes of, as well as disrupt, feeding-related stereotypic activity in both walruses and polar bears, we attempted to take into account not only the likelihood of allowing the organism to consume food as a way to examine and disrupt stereotypic activity, but the way the animal would typically come into contact with and consume their food in the wild.

This was particularly true for the walrus experiments, where we manipulated how the walruses typically come into contact with food in an attempt to take into consideration the role of flipper use, and using their vibrissae and mouths to locate food prior to extracting it. In contrast, the polar bears spend the majority of their time attempting to locate, move toward, and capture prey. Consumption of food is relatively rapid once it is acquired. By drawing out the amount of time from when prey was discovered to when the animal had eaten its fill, we thought to continue to engage the amount of local search behavior the animal had to engage in to get a meal. The timing of food deliveries were thus the primary concern for polar bears, since a polar bear attempting to locate and move towards prey encompasses the majority of polar bear

foraging, and consumption of food once located and contacted involves only a small fraction of that time.

In both cases the animals were offered the opportunity to engage in more ecologically relevant appetitive search behaviors. The bears could well have waited until the big meal of the day was delivered within a few hours. Instead they attended more carefully during food schedules to the environment with non-stereotypic activity, sniffing, air licking, and more evenly distributed locomotion. Similarly, the walruses could have waited until their next scheduled feeding. Instead they increased contacting foraging devices and decreased stereotypic activity and increased non-stereotypic activity when such devices allowed for manipulating them to obtain food.

It is worth pointing out that more is involved than putting the animals on an FT or VT schedule using small amounts of food (although that appears to be a worthwhile start for the bears). Rather, linking the way the food is presented to the type of foraging behavior shown by the animals under somewhat comparable conditions, appears to play an important role both in understanding the function of their stereotypic activity, and figuring out how to mitigate the conditions engaging and supporting stereotypic activity.

This paper proposes a general approach to help discover the ecologically relevant aspects of feeding by focusing on the ways animals forage in the wild, not just distinguishing carnivore, omnivore, and herbivore, and discovering favored foods, but specifically with respect to the relevant investment and in behavioral specializations related to general search, focal search, and consummatory behavior. Once the behavioral expressions and controlling stimuli are clarified, it is possible to examine the what, when, and how of typical feeding procedures for their potential contributions to stereotypic

activity. Given an initial set of behaviors and concepts, it seems clear that manipulations of proposed feeding patterns will help further refine the mechanisms of foraging in different animals. In this way the contribution of the captive environment may be important in the study of a species by allowing important cues and patterns of foraging behavior to be discovered for otherwise difficult to observe species in the wild.

A final issue is whether all stereotypic activity in captive animals is related to feeding—it seems highly unlikely. But two points are worth making. Feeding is an extremely important behavior for which many specializations of search, procurement, and intake will have occurred. Second, stereotypic activity with respect to other important motivational systems should be at least partly susceptible to a similar approach exploring the origins of stereotypic activity and their mitigation. The fact is that many keepers working with animals know a great deal about the variables controlling other stereotypic activity; it may be that their knowledge can be incorporated in a more formal structure similar to that used here for feeding, a structure that could be used to encourage alternatives to stereotypic activity.

References

Altmann, J. (1994). Observational study of behavior: Sampling Methods. *Behaviour, 49,* 227-265.

Amstrup, S. C., Durner, G. M., Stirling, I., Lunn, N. J. & Messier, F. (2000). Movements and distribution of polar bears in the Beaufort Sea. *Canadian Journal of Zoology 78,* 948–966.

Baker, K. C. & Easley, S. P. (1996). An analysis or regurgitation and reingestion in captive chimpanzees. Applied Animal Behaviour Science, 49, 403-415.

Bloomsmith, M. A., & Lambeth, S. P. (1995). Effects of predictable versus unpredictable feeding schedules on chimpanzee behavior. *Applied Animal Behaviour Science, 44,* 65-74.

Broom, D. M. (1986). Indicators of poor welfare. *The British Veterinary Journal, 142,* 524-526.

Carlstead, K., Seidensticker, J. (1991). Seasonal variation in stereotypic pacing in an American black bear (*Ursus americanus*). *Behavioural Processes, 25,* 155-161.

Carlstead, K., Seidensticker, J., and Baldwin, R. (1991). Environmental enrichment for zoo bears*. Zoo Biology, 10,* 3-16.

Clubb, R. E. & Mason, G. J. (2003). Captivity effects on wide-ranging carnivores. *Nature, 425,* 473-474.

Cooper, J. J., & Ödberg, F. O. (1991). The emancipation of stereotypies with age. In: Appleby, M. C., Howell, R. I., Petherick, S. C., & Rutter, S. M. (Eds.). *Applied animal behaviour: past, present and future* (p. 142). Wheathampstead, UK: Universities Federation for Animal Welfare.

Dawkins, M. S. (1990). From an animal's point of view: motivation, fitness, and animal

welfare. *Behavioral and Brain Sciences, 13,* 1.

Derocher, A. E., Lunn, N. J., Stirling, I. (2004). Polar bears in a warming climate.

Integrative and Comparative Biology, 44, 163-176.

Fagen, R. M. (1981). *Animal Play Behavior.* New York: Oxford University Press.

Forthman, D. L. & Ogden, J. J. (1992). The role of applied behavior analysis in zoo

management: today and tomorrow. *Journal of Applied Behavior Analysis, 25*,

647-652.

Hemstock, A. (1999). *The Polar Bear.* Mankato, MN: Capstone Press.

Jones, M. & Pillay, N. (2004). Foraging in captive hamadryas baboons: implications for

enrichment. *Applied Animal Behaviour Science, 88*, 101-110.

Kastelein, R. A., Gerrits, N. M., & Dubbeldam, J. L. (1991). The anatomy of the Walrus

head (*Odobenus rosmarus*). Part 2: The Description of the muscles and of their

role in feeding and haul-out behaviour. *Aquatic Mammals, 17,* 156-180.

Kastelein, R. A. & Mosterd, P. (1989). The excavation technique for mollusks of Pacific

Walruses (*Odobenus rosmarus divergens*) under controlled conditions. *Aquatic

Mammals, 15.1*, 3-5.

Kastelein, R. A., Paase, M., Klinkhamer, P., & Wiepkema, P. R. (1991). Food dispensers

as occupational therapy for the Walrus (*Odobenus rosmarus divergens*) at the

Harderwijk Marine Mammal Park. *International Zoo Yearbook, 30*, 207-212.

Kastelein, R. A. & Wiepkema, P. R. (1989). A digging trough as occupational therapy for

Pacific Walruses (*Odobenus rosmarus divergens*) in human care. *Aquatic

Mammals, 15.1*, 9-17.

Lampard, K. (2002). The effects of movable novel objects, novel olfactory stimuli and

    novel auditory stimuli on the exploratory, play and stereotypical behaviour of

    captive species: A comparative study. Unpublished Ph.D. Dissertation, University

    of Adelaide (Australia).

Lawrence, A. B., & Terlouw, E. M. C. (1993). A review of behavioral factors involved in

    the development and continued performance of stereotypic behaviors in pigs.

    Journal of Animal Science, 71, 2815-2825.

Levermann, N., Galatius, A., Ehlme, G., Rysgaard, S., & Born, E. W. (2003). Feeding

    behaviour of free-ranging walruses with notes on apparent dextrality of flipper

    use. *BMC Ecology, 3,* 1-13.

Loizos, C. (1966). Play in mammals. *Symposia of the Zoological Society of London, 18,*

    1-9.

Lucas, G. A., Timberlake, W., & Gawley, D. J. (1988). Adjunctive behavior in the rat

    under periodic food delivery in a 24-hr environment. *Animal Learning &*

    Behavior, 16, 19-30.

Markowitz, H. & LaForse, S. (1987). Artificial prey as behavioral enrichment devices

    For felines. *Applied Animal Behaviour Science, 18*, 31-43.

Mason, G. J. (1991a). Stereotypies: A critical review. *Animal Behaviour, 41*, 1015.

Mason, G. J. (1991b). Stereotypies and suffering. *Behavioural Processes, 25*, 103-115.

Mason, G. J. (1993). Age and context affect the stereotypies of caged mink. *Behaviour,*

    127, 191-229.

McGreevy, P., & Nicol, C. (1998). Physiological and behavioral consequences associated with short-term prevention of crib-biting in horses. *Physiology and Behavior, 65,* 15-23.

Mountaudouin, S., & Le Pape, G. (2004). Comparison of the behaviour of European brown bears (*Ursus arctos arctos*) in six different parks, with particular attention to stereotypies. *Behavioural Processes, 67,* 235-244.

Nelson, C. H., & Johnson, K. R. (1987). Whales and walruses as tillers of the sea floor. *Scientific American, 256,* 112-117.

Ödberg, F. (1978). Abnormal behaviours: (stereotypies). In: *Proceedings of the 1st World Congress on Ethology Applied to Zootechnics, 475*. Madrid, Spain.

Pell, S. M., & McGreevy, P. D. (1999). A study of cortisol and beta-endorphin levels in stereotypic and normal thoroughbreds. *Applied Animal Behaviour Science, 64*, 81-90.

Poling, A., Methot, L. L., & LeSage, M. G. (1995). Fundamentals of Behavior Analytic Research. New York: Plenum Press.

Rosing, N. (1996). *The World of the Polar Bear.* Willowdale, ON: Firefly Books Ltd.

Schmid, J., Heistermann, M., Ganslober, U., & Hodges, J. K. (2001). Introduction of foreign female Asian elephants (*Elephas maximus*) into an existing group: behavioural reactions and changes in cortisol levels. *Animal Welfare, 10,* 357-372.

Shepherdson, D. J., Carlstead, K., Mellen, J. D., & Seidensticker, J. (1993). The influence of food presentation on the behavior of small cats in confined environments. *Zoo Biology, 12*, 203-216.

Schoenecker, B, Heller, K. E., & Freimanis, T. (2000). Development of stereotypies and

    polydipsia in wild caught bank voles (*Clethrionomys glareolus*) and their

    laboratory-bred offspring: Is polydipsia a symptom of diabetes mellitus? *Applied*

    Animal Behaviour Science, 68, 349-357.

Stevenson, M. F. (1983). The captive environment: its effect on exploratory and related

    behavioural responses in wild animals. In: Exploration in Animals and Man, 7,

    176-197. Ed. J. Archer and L. Birke. Berkshire, U. K.: Van Nostrand Reinhold.

Stirling, I. (1988). *Polar Bears.* Ann Arbor, MI: University of Michigan Press.

Swaisgood, R.R., & Shepherdson, D.H. (2005). Scientific approaches to enrichment and

    stereotypies in zoo animals: what's been done and where should we go next? *Zoo*

    Biology, 24, 499-518.

Therrien, C. L., Gaster, L., Cunningham-Smith, P., Manire, C. A. (2007). Experimental

    evaluation of environmental enrichment of sea turtles. *Zoo Biology, 26,* 407-416.

Timberlake, W. (1997). An animal-centered, causal-system approach to the

    understanding and control of behavior. *Applied Animal Behaviour Science*, *53*,

    107-129.

Timberlake, W. (2001). Motivational modes in behavior systems. In R. R. Mowrer and

    S. B. Klein (Eds.), *Handbook of contemporary learning theories* (pp.155-209).

    Hillsdale NJ: Erlbaum Associates.

U. S. Fish and Wildlife Service (2006). The polar bear *(Ursus maritimus)*. U. S. Fish and

    Wildlife Service, Washington, DC. Available at

    http://www.fws.gov/home/feature/2006/polarbear.pdf.

Wechsler, B. (1991). Stereotypies in polar bears. *Zoo Biology, 10,* 177-188.

Wechsler, B. (1992). Stereotypies and attentiveness to novel stimuli: A test in polar

bears. *Applied Animal Behaviour Science, 33,* 381-388.

Weller, S. H. & Bennett, C. L. (2001). Twenty-four hour activity budgets and patterns of

behavior in captive ocelots (*Leopardus pardalis*). *Applied Animal Behaviour*

Science, 71, 67-79.

Table 1.

Behaviors, classes of behavior, and definitions for each response in the ethogram. Behaviors in classes marked with a * must occur in conjunction with a behavior in a non-* class.

Behavioral Class and Behaviors (abbreviations)	Definition
Stereotypy	
Pacing (P)	Repetitive moving pattern on land. Must occur 2 or more times (e.g., one full back-forth motion) w/o more than a 2 s pause.
Circle Swimming (CS)	Repetitive swimming pattern. Must be at least one lap around the rock.
Pace Swimming (PS)	Repetitive swimming pattern. Same as definition for pacing, but in water.
Inactive	
Sitting (Si)	Posterior and back hind legs on floor while maintaining an upright position.
Lying Down (LD)	At least part of back on the ground (any down position that doesn't meet the sitting definition).
Social	
Interacting w/ Other Bear (IOB)	Oriented towards the other bear w/o vocalization.
Vocalization (V)	Same as IOB, but with a vocalization. Vocalization must occur while oriented towards another bear.
Active	
Standing (St)	Non-movement standing (3 or 4 paws on the ground with no locomotion).
Rearing (R)	Rearing up on back two legs.
Locomotion (L)	Directional, non-repetitive movement.
Nonpatterned Swimming (NS)	Swimming that doesn't meet a stereotypy definition. This includes standing or floating when completely submerged in the water.
Manipulating Object	Any body contact with a mobile, non-edible object.

Table 1 (continued).

Behavioral Class and Behaviors (abbreviations)	Definition
Food Directed*	
Eating (E)	Mouth contact with any edible item (including drinking).
Licking Air (LA)	Sticking tongue out without contact to any object.
Sniffing (Sn)	Bridge of nose breaking the horizontal plane. Cannot be on back or swimming on back for this to occur.
Groom*	
Licking Paws/Body (LP)	Licking, usually at paws, but on any Part of the body.
Scratching Body (SB)	Contact with paw or mouth (w/o licking) to the body, or rubbing body against a non-mobile object.
Other	
Urinating or Defecating (UD)	Bear urinates or defecates.
Out of Sight (OS)	Bear is not visible to the observer.
Other (O)	Bear engages in a behavior that does not meet the above behaviors.

Table 2.

Mean Food Directed Percentages (and Standard Error of the Mean in Parentheses) with the Eating behavior included or Not Included in the Score. Stars indicate a significant difference between the two conditions.

Condition - Bear	Fd Dir w/ Eat %	Fd Dir w/o Eat %	Eat %
BL			
Tundra	N/A	5.9 (0.9)	N/A
Pasha	N/A	7.0 (1.2)	N/A
COMBINED	N/A	6.4 (0.7)*	N/A
FT-1'			
Tundra	21.2 (2.9)	11.1 (2.6)	10.1 (0.9)
Pasha	21.8 (4.8)	11.7 (3.1)	10.2 (3.0)
COMBINED	21.4 (2.4)	11.3 (2.0)*	10.0 (1.1)
FT-5'			
Tundra	9.3 (0.8)	6.9 (0.9)	2.4 (0.4)
Pasha	11.0 (2.1)	9.0 (1.9)	2.0 (0.8)
COMBINED	9.9 (0.9)	7.6 (0.8)	2.3 (0.4)
FT-10'			
Tundra	10.8 (1.7)	8.3 (1.6)	2.6 (0.3)

Table 3.

Behaviors, classes of behavior, and definitions for each response in the ethogram.

Behavioral Class and Behaviors (abbreviations)	Definition
Active	
Non-patterned Swimming (NS)	Swimming in an irregular or non-patterned way.
Non-patterned Swimming w/ Contact (NC)	Same as NS, but with contact to a pool surface by face/vibrissae.
Land Active (LA)	Moving or exploring a surface/object on land.
Mat Contact (MC)	Face-vibrissae contact on a foraging mat.
Other Contact (OC)	Contact with a manipulable object other than the mat.
Social	
Interacting w/ Other Walrus (IOW)	Any body contact with another walrus.
Vocalization at Walrus (V)	Vocalizing while oriented towards another walrus. Vocalization must occur while oriented towards another walrus (non-oriented grunts do not count).
Inactive	
Resting (R)	Bobbing/non-movement in the water.
Land Resting (LR)	Same as R, but on land.
Stereotypy	
Circle Swimming (CS)	Swimming in a repetitive pattern, with at least 1 complete circle.
Circle Swimming w/ Contact (CC)	Same as CS, but with contact to a pool surface by face/vibrissae.
Flipper Sucking (FS)	Contact of face/vibrissae to flipper with a continued sucking motion (usually done while resting).
Whistling (W)	Repetitive high-pitched whistling pattern, done in several consecutive bursts (previously observed in Brutus).
Other	
Out of Sight (OS)	Walrus is not visible to the observer.
Other (O)	Walrus engages in a behavior that does not meet the above behaviors.

Figure Captions

Figure 1. Hypothesized carnivore foraging systems in the wild and in captivity.

Figure 2. The polar bear enclosure. I – V represent the five areas the polar enclosure was divided into in order to observe the location of the polar bear throughout the study.

Figure 3. Mean percentage of occurrence (with SE bars) for Tundra for three classes of behavior (Stereotypy, Inactive, and Active) across all four conditions (BL, FT1', FT5', and FT10'). The top graph shows the classes of behavior for the Before condition, the middle graph for the During condition (when feeding schedules were in place), and the bottom graph for the After condition. Asterisks and solid lines indicate significant differences between two conditions ($p < .05$), while asterisks and dotted lines indicate differences that approached significance ($p < .10$).

Figure 4. Mean percentage of occurrence (with SE bars) for Pasha for three classes of behavior (Stereotypy, Inactive, and Active) across all three conditions (BL, FT1', and FT5'). The top graph shows the classes of behavior for the Before condition, the middle graph for the During condition (when feeding schedules were in place), and the bottom graph for the After condition. Asterisks and solid lines indicate significant differences between two conditions ($p < .05$), while asterisks and dotted lines indicate differences that approached significance ($p < .10$).

Figure 5. Mean Entropy (variability in enclosure use) score (with SE bars) across all four possible conditions (BL, FT1', FT5', and FT10' [Tundra only]) for all three observation periods: before, during, and after. Lower Entropy scores demonstrate decreased variability in the use of the different enclosure areas. The top graph shows Tundra's Entropy scores, while the bottom graph shows Pasha's Entropy scores. Asterisks and

solid lines indicate significant differences between two conditions (p<.05), while

asterisks and dotted lines indicate differences that approached significance (p<.10).

Figure 6. Mean percentage of occurrence for four classes of behavior (Stereotypy,

Inactive, Nonmovement, and Active) during each 15 s pinpoint sample of a treatment

condition. The left three graphs represent Tundra's results, while the two right graphs

represent Pasha's results. The two top graphs are for the FT1' condition, the two middle

graphs for the FT5' condition, and the bottom graph for the FT10' condition.

Figure 7. Mean percentage of occurrence (with SE bars) for Tundra between the

experimental (FT) and control (C) conditions. Baseline (from experiment 1) is

represented by a solid black circle, and the FT conditions and their controls run from 1'

to 10' along the x-axis. Before periods are represented on the left, while during periods

are represented on the right. The two top graphs are for the Stereotypy class, the middle

graphs for the Inactive class, and the bottom graphs for the Active class of behaviors.

Figure 8. Mean percentage of occurrence (with SE bars) for Tundra for three classes of

behavior (Stereotypy, Inactive, and Active) across all three conditions BL, VT1', and

VT5'). The top graph shows the classes of behavior for the Before condition, the middle

graph for the During condition (when feeding schedules were in place), and the bottom

graph for the After condition. Asterisks and solid lines indicate significant differences

between two conditions (p<.05), while asterisks and dotted lines indicate differences that

approached significance (p<.10).

Figure 9. Mean Entropy (variability in enclosure use) score (with SE bars) for Tundra

across all three possible conditions (BL, VT1', and VT5') for all three observation

periods: Before, During, and After. Lower Entropy scores demonstrate decreased

variability in the use of the different enclosure areas. Asterisks and solid lines indicate significant differences between two conditions (p<.05), while asterisks and dotted lines indicate differences that approached significance (p<.10).

Figure 10. Mean percentage of occurrence (with SE bars) for Triton for three classes of behavior (Stereotypy, Inactive, and Active) across the two conditions (BL and Spray). The top graph shows the classes of behavior for the Before condition, the middle graph for the During condition (when the Spray schedule was in use), and the bottom graph for the After condition. Asterisks and solid lines indicate significant differences between two conditions (p<.05), while asterisks and dotted lines indicate differences that approached significance (p<.10).

Figure 11. Mean Entropy (variability of enclosure use) score and mean percentage of occurrence (with SE bars) for Triton for four classes of behavior (Stereotypy, Inactive, Social, and Active) across two conditions (Triton on Exhibit with Tundra, or Triton Alone). The top graph shows the mean Entropy score between the two conditions, and the bottom graph shows the Tritons percentage of occurrence for the four classes of behavior between the two conditions. Asterisks and solid lines indicate significant differences between two conditions (p<.05), while asterisks and dotted lines indicate differences that approached significance (p<.10).

Figure 12. Mean percentage of occurrence (with SE bars) between morning Baseline sessions (8 days) and all Afternoon sessions (11 days) for all five classes of behavior (Active, Social, Inactive, Stereotypy, and Other) across all four conditions (BL, M, MF, and F). The top graph shows the classes of behavior for Brutus, the middle graph for

Aurora, and the bottom graph for Nereus. Asterisks and dotted lines indicate differences that approached significance (p<.10).

Figure 13. Mean percentage of occurrence (with SE bars) for Mat Contact behaviors across the Mat Alone (M) and Mat with Food (MF) conditions. The top graph shows the first ½ hr after the mat was introduced, and the bottom graph the second ½ hr. Asterisks and solid lines indicate significant differences between two conditions (p<.05).
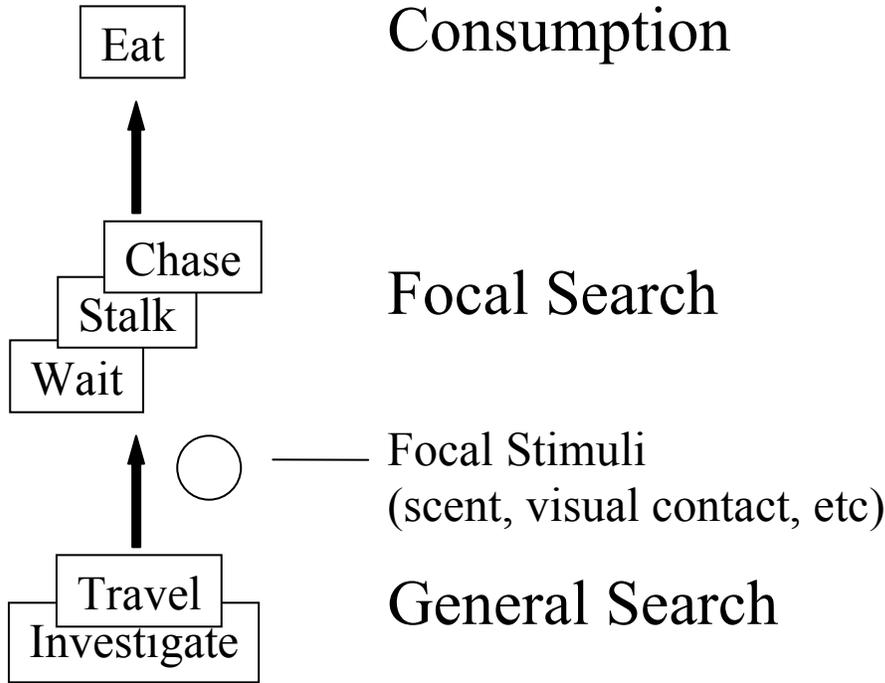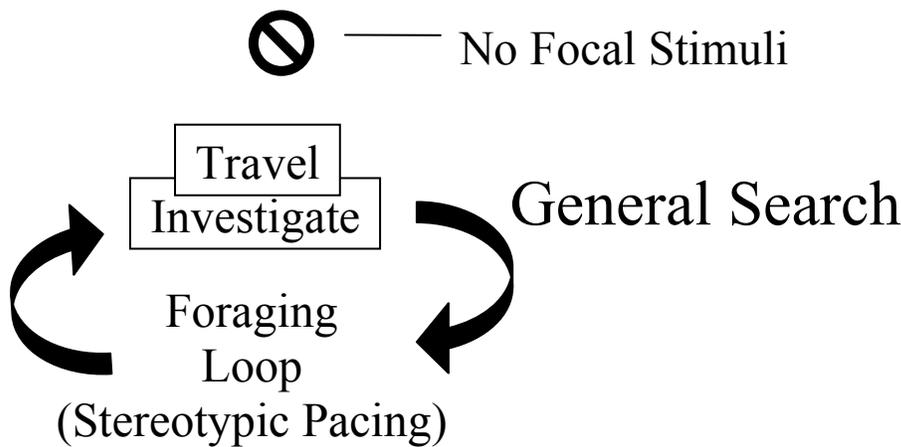
Figure 14. Mean percentage of occurrence (with SE bars) in the first ½ hr for all five classes of behavior (Active, Social, Inactive, Stereotypy, and Other) across all four conditions (BL, M, MF, and F). The top graph shows the classes of behavior for Brutus, the middle graph for Aurora, and the bottom graph for Nereus. Asterisks and solid lines indicate significant differences between two conditions (p<.05), while asterisks and dotted lines indicate differences that approached significance (p<.10).

Figure 15. Mean percentage of occurrence (with SE bars) in the second ½ hr for all five classes of behavior (Active, Social, Inactive, Stereotypy, and Other) across all four conditions (BL, M, MF, and F). The top graph shows the classes of behavior for Brutus, the middle graph for Aurora, and the bottom graph for Nereus. Asterisks and solid lines indicate significant differences between two conditions (p<.05).

Figure 16. Mean percentage of occurrence (with SE bars) for Ball Contact behaviors across the Ball Alone (B) and Ball with Food (BF) conditions. The top graph shows the first ½ hr after the mat was introduced, and the bottom graph the second ½ hr. Asterisks and solid lines indicate significant differences between two conditions (p<.05).

Figure 17. Mean percentage of occurrence (with SE bars) in the first ½ hr for all five classes of behavior (Active, Social, Inactive, Stereotypy, and Other) across both

conditions (B and BF). The top graph shows the classes of behavior for Brutus, the

middle graph for Aurora, and the bottom graph for Nereus. Asterisks and solid lines

indicate significant differences between two conditions (p<.05), while asterisks and

dotted lines indicate differences that approached significance (p<.10).

Figure 18. Mean percentage of occurrence (with SE bars) in the second ½ hr for all five

classes of behavior (Active, Social, Inactive, Stereotypy, and Other) across both

conditions (B and BF). The top graph shows the classes of behavior for Brutus, the

middle graph for Aurora, and the bottom graph for Nereus. Asterisks and solid lines

indicate significant differences between two conditions (p<.05).

Figure 19. Percentage of ball contact per session during the first ½ hr of the BF

condition.

Carnivore Foraging in the Wild

Eat — **Consumption**

Chase / Stalk / Wait — **Focal Search**

○ —— Focal Stimuli (scent, visual contact, etc)

Travel / Investigate — **General Search**

Carnivore Foraging in Captivity

🚫 —— No Focal Stimuli

Travel / Investigate — **General Search**

Foraging Loop (Stereotypic Pacing)

Polar bear Enclosure

BEFORE

PASHA

DURING

% OF OCCURRENCE

BL
FT1'
FT5'

AFTER

Stereo
Inactive
Active
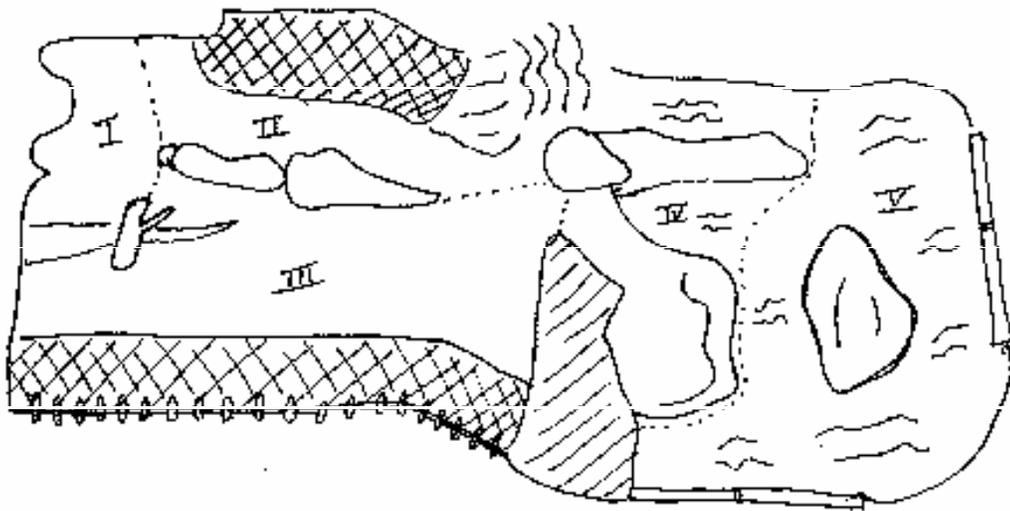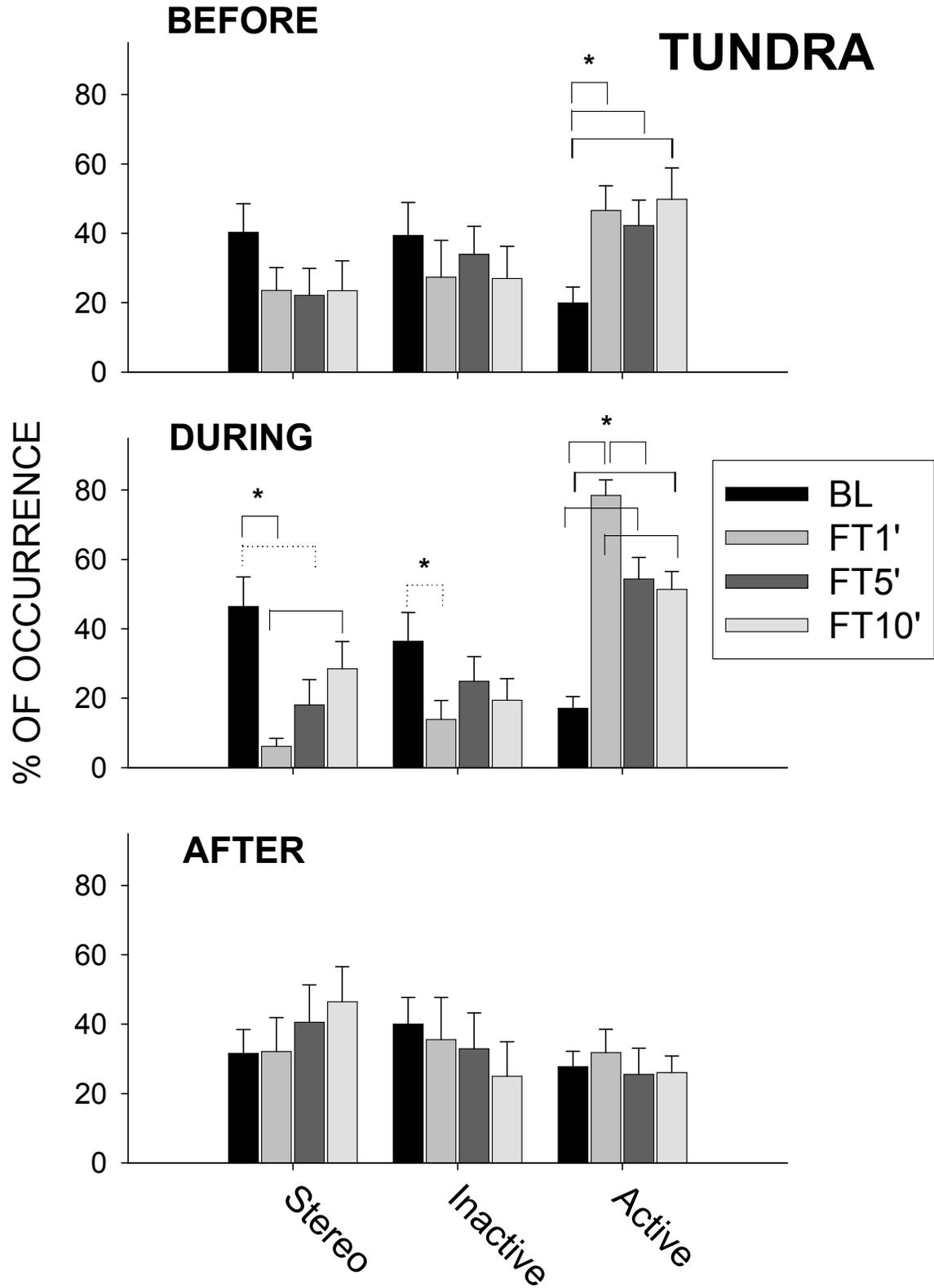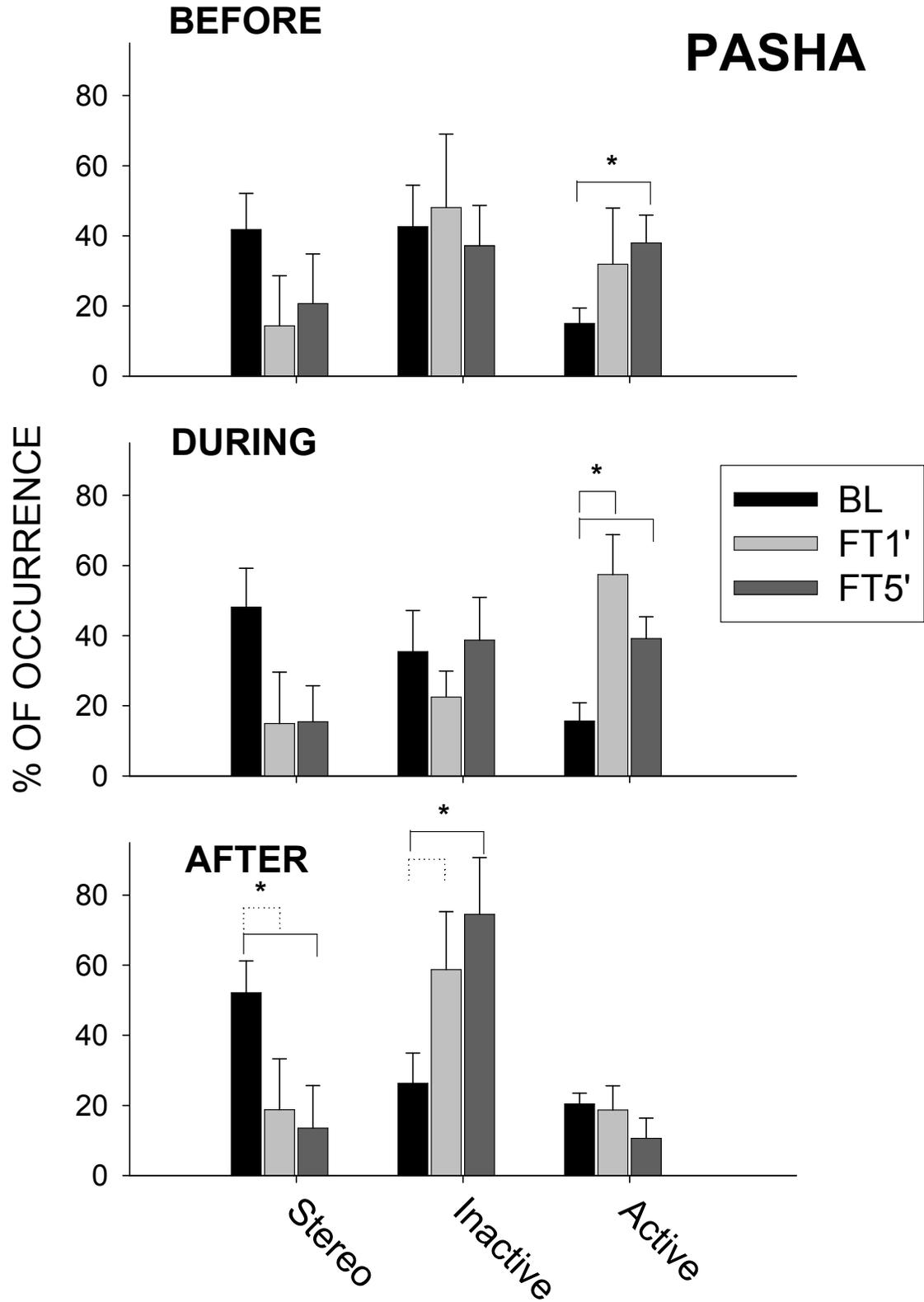
ENTROPY

(Variability of Enclosure Use)
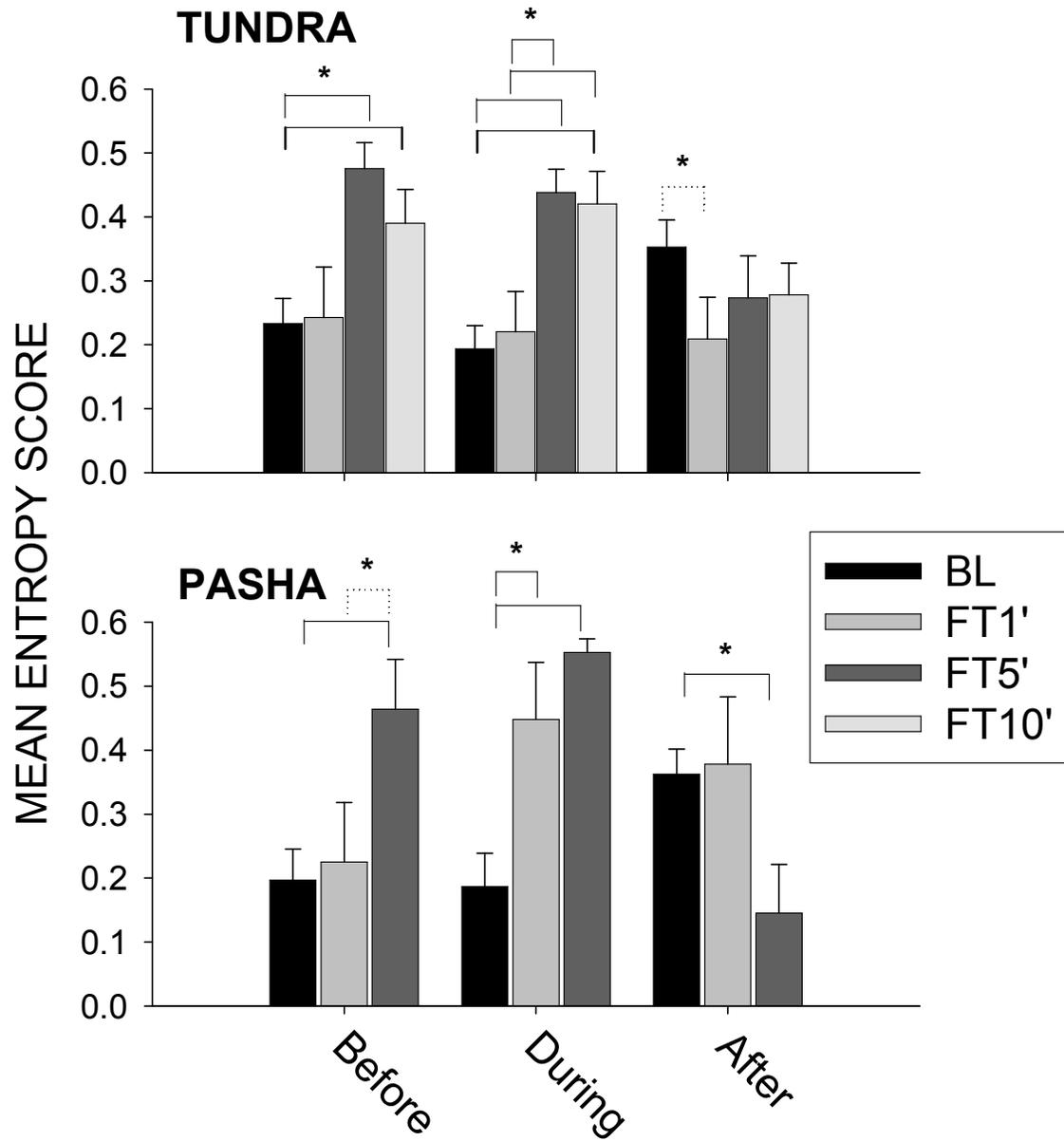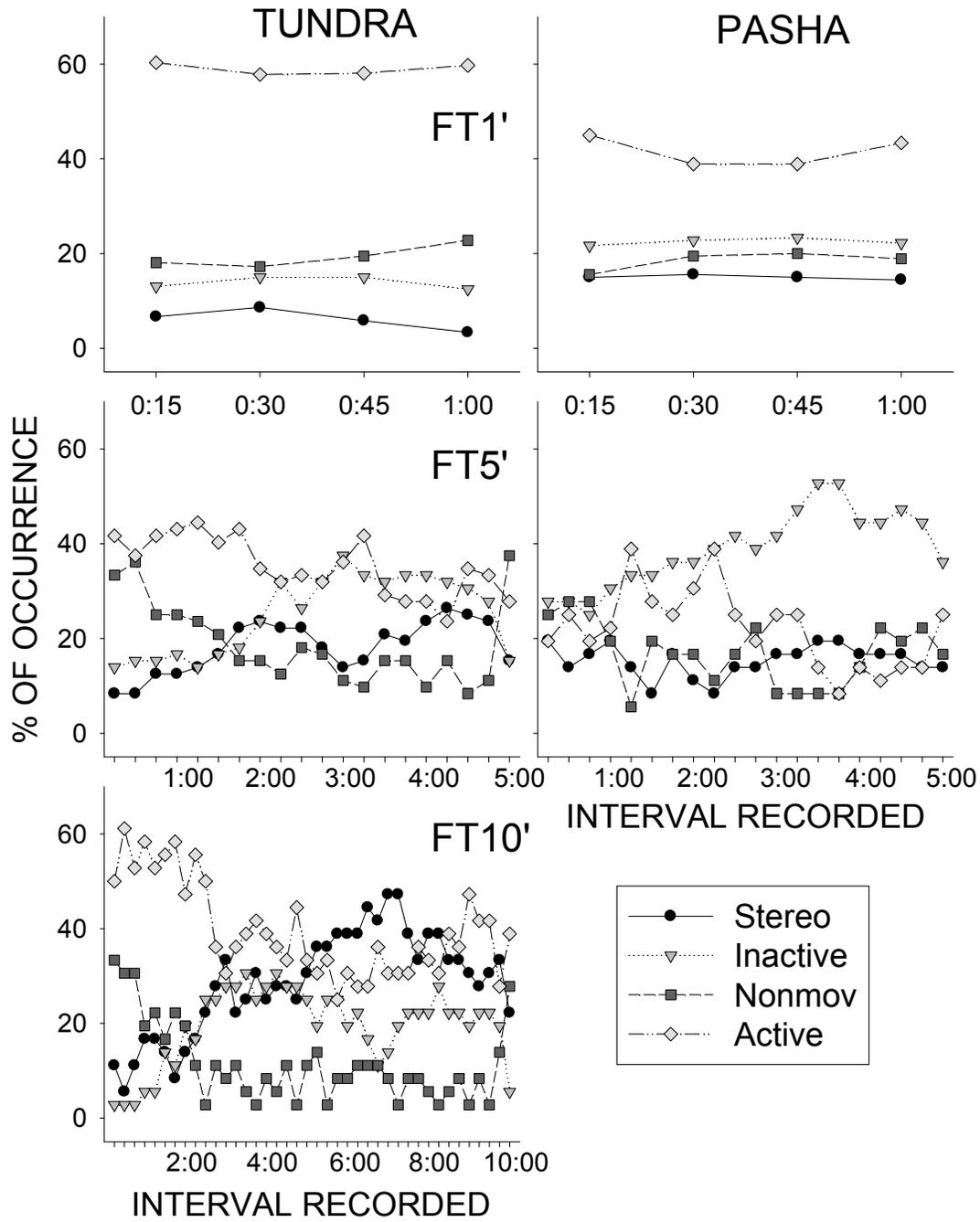
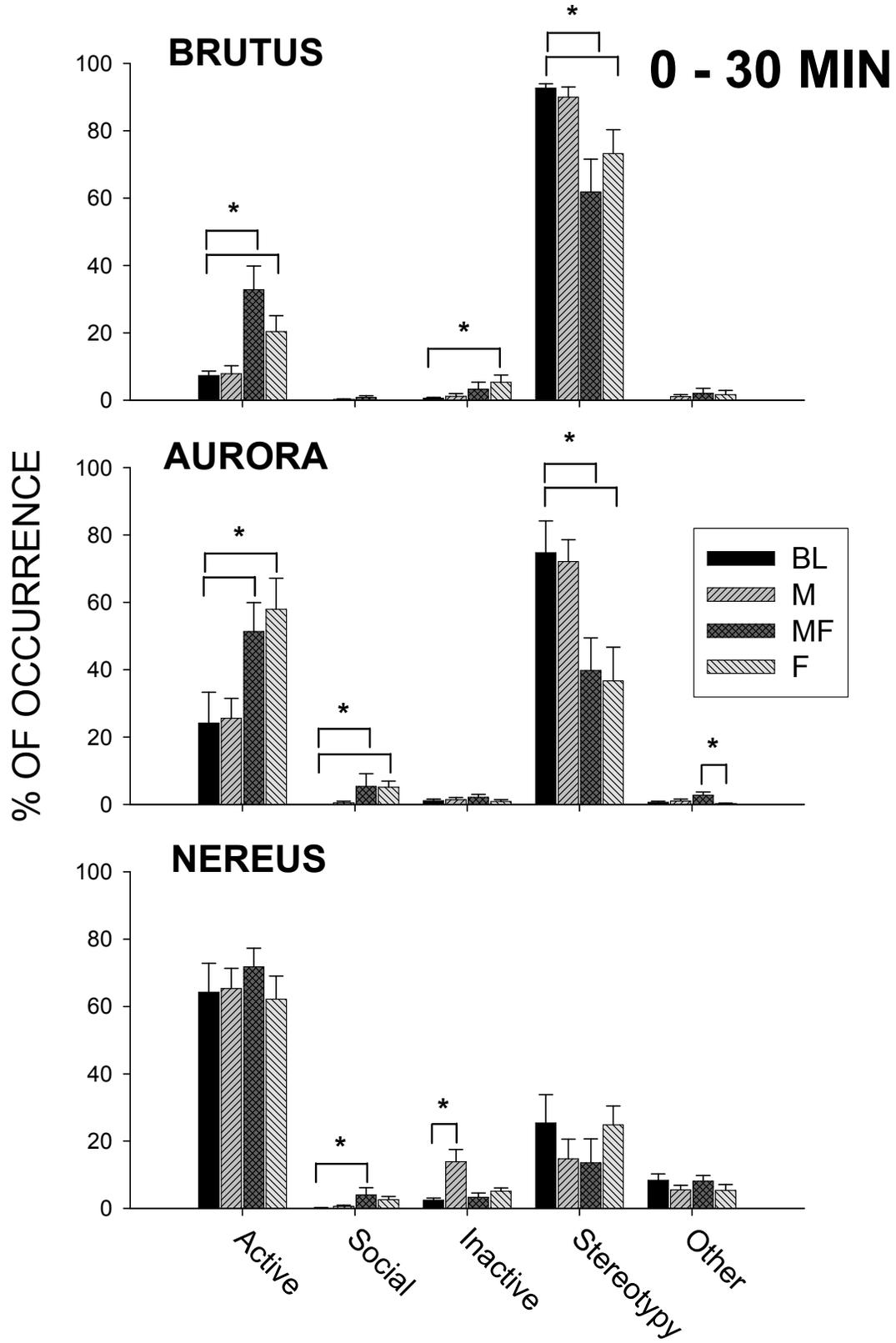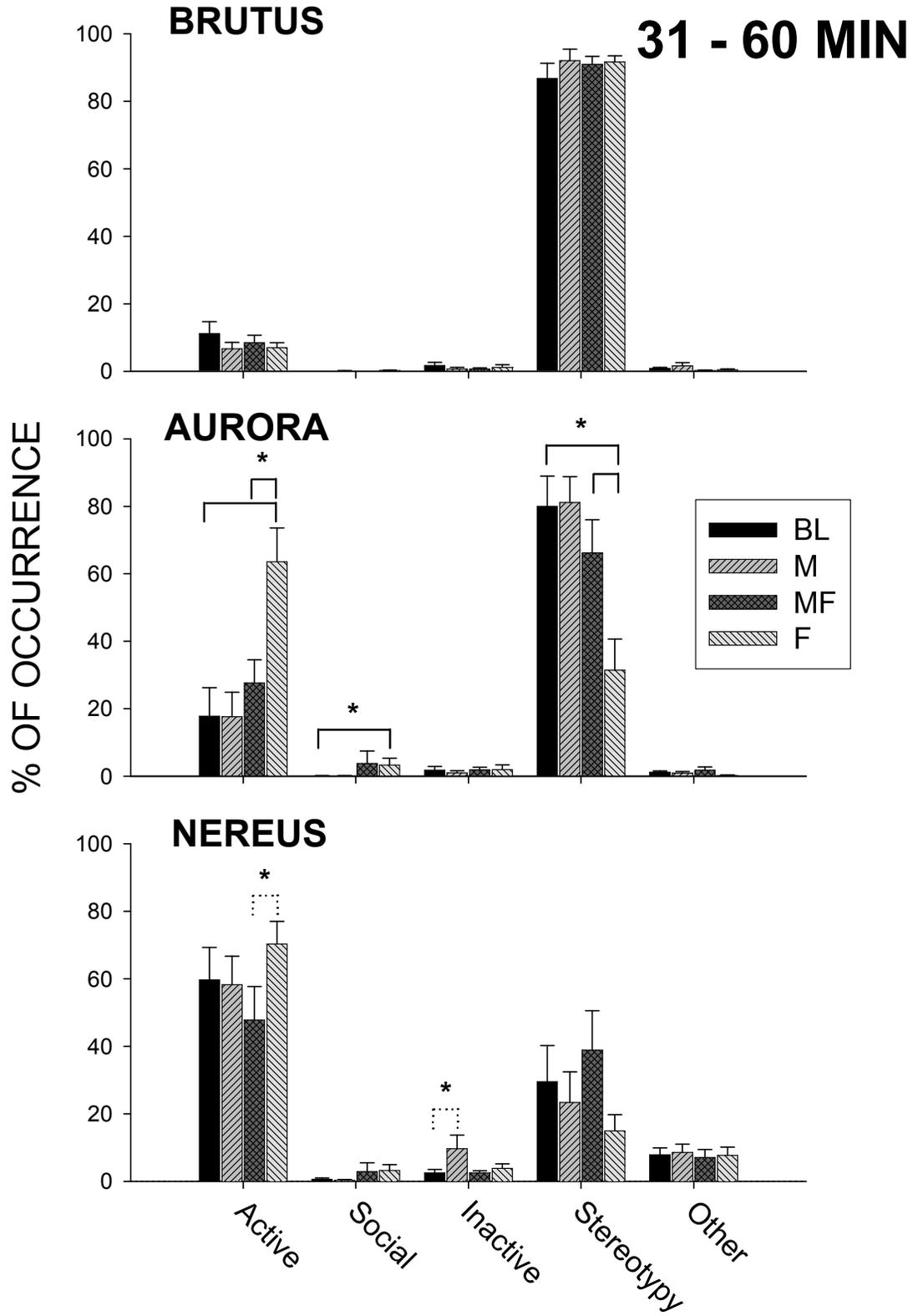**STEREOTYPY**
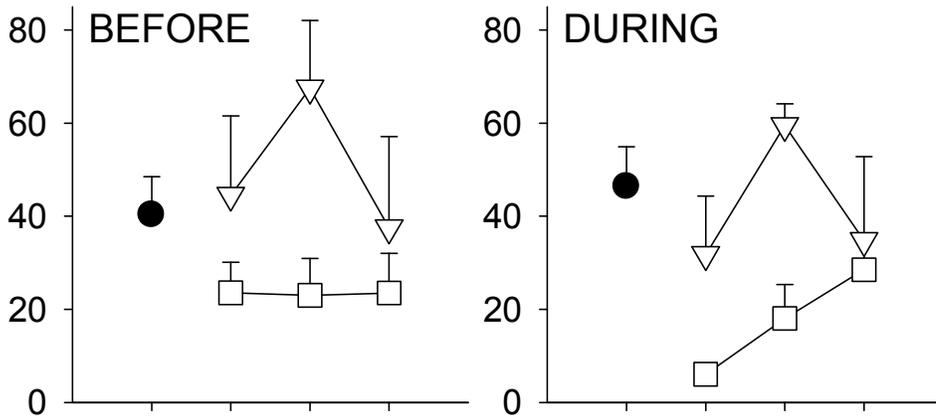
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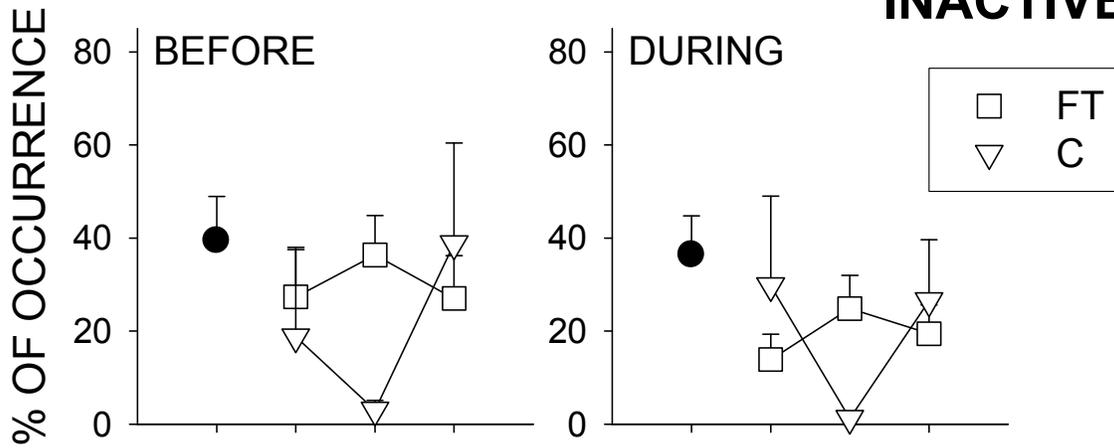
ACTIVE
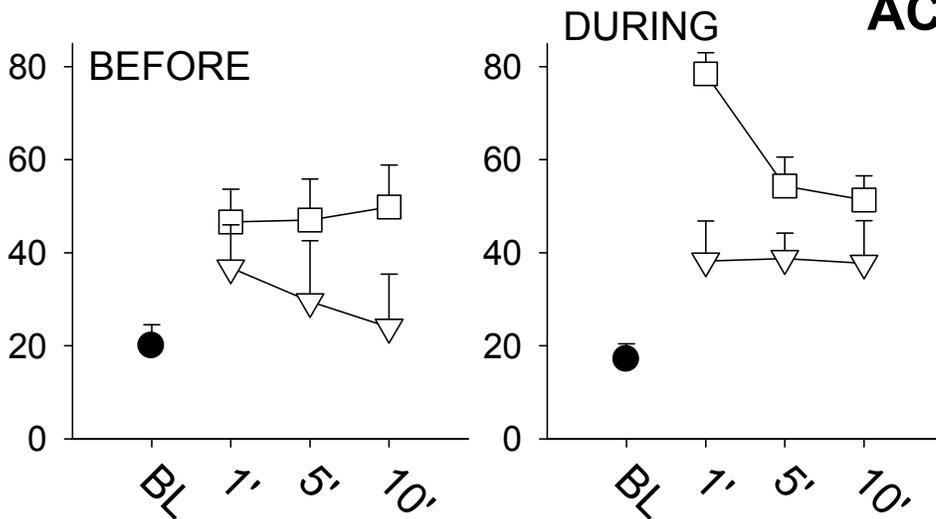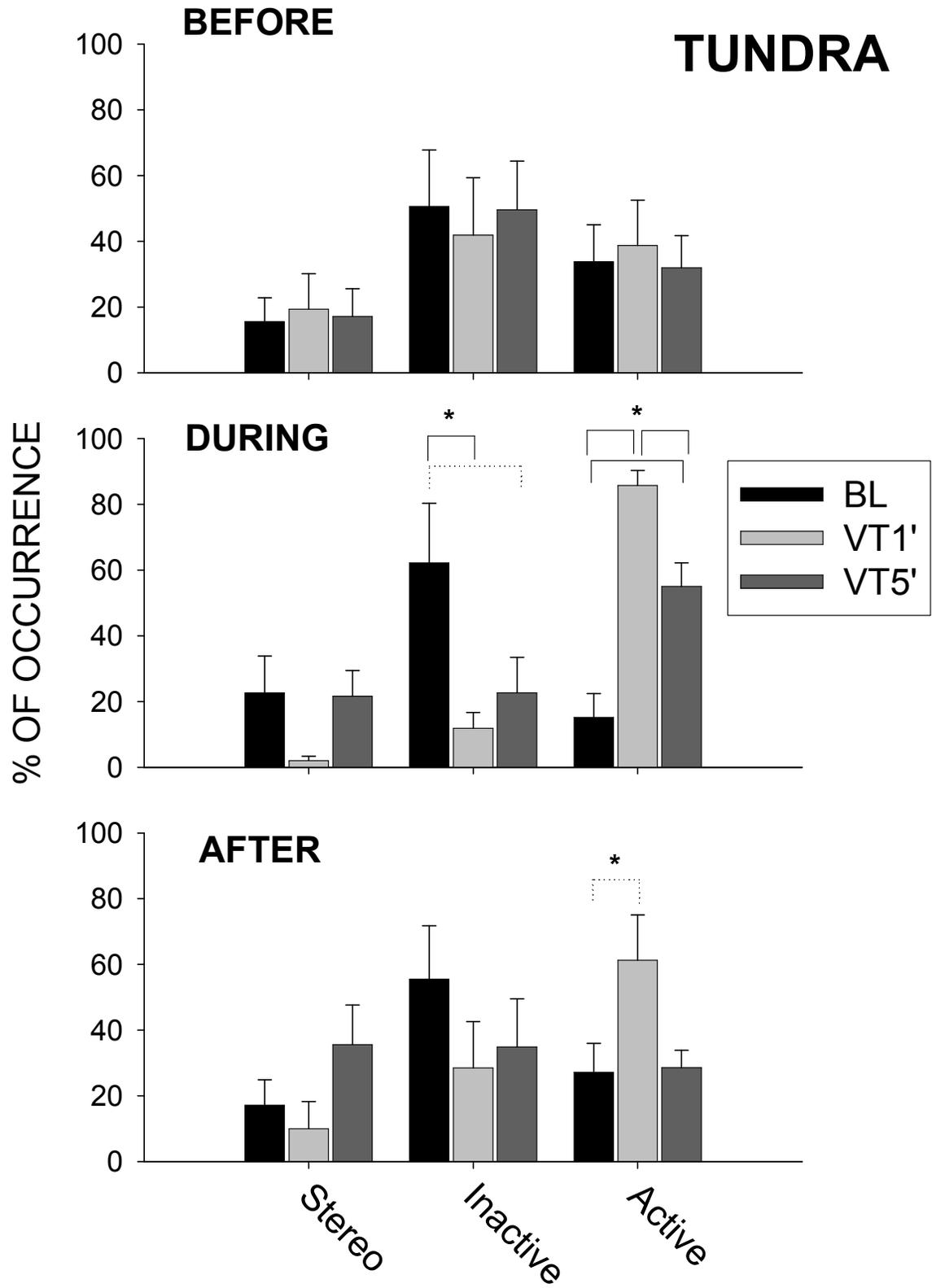
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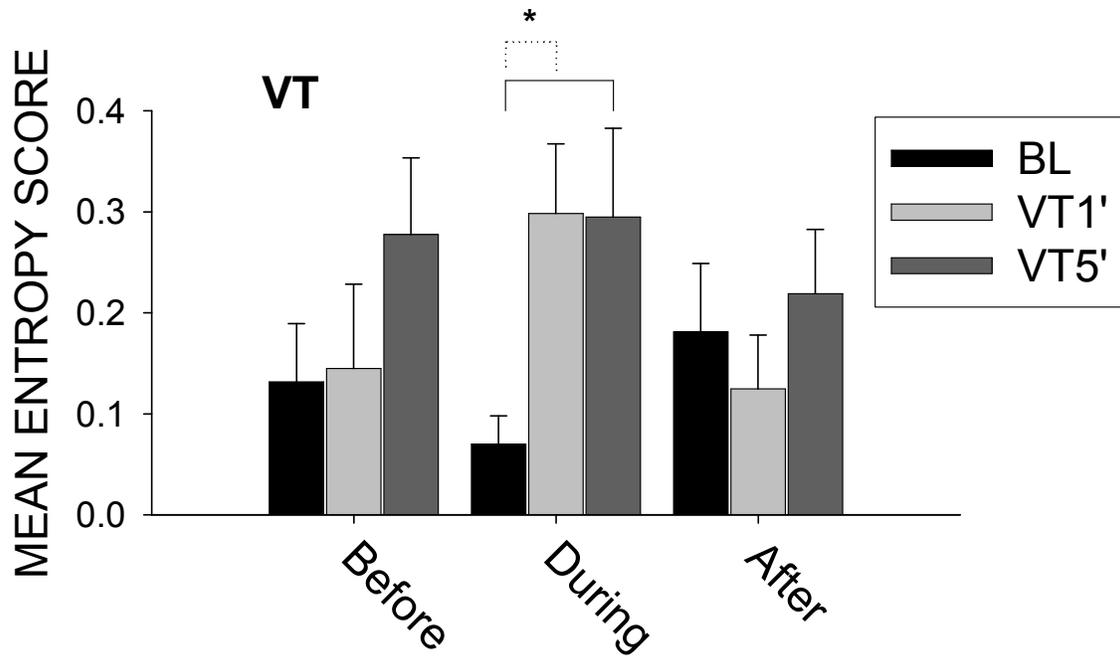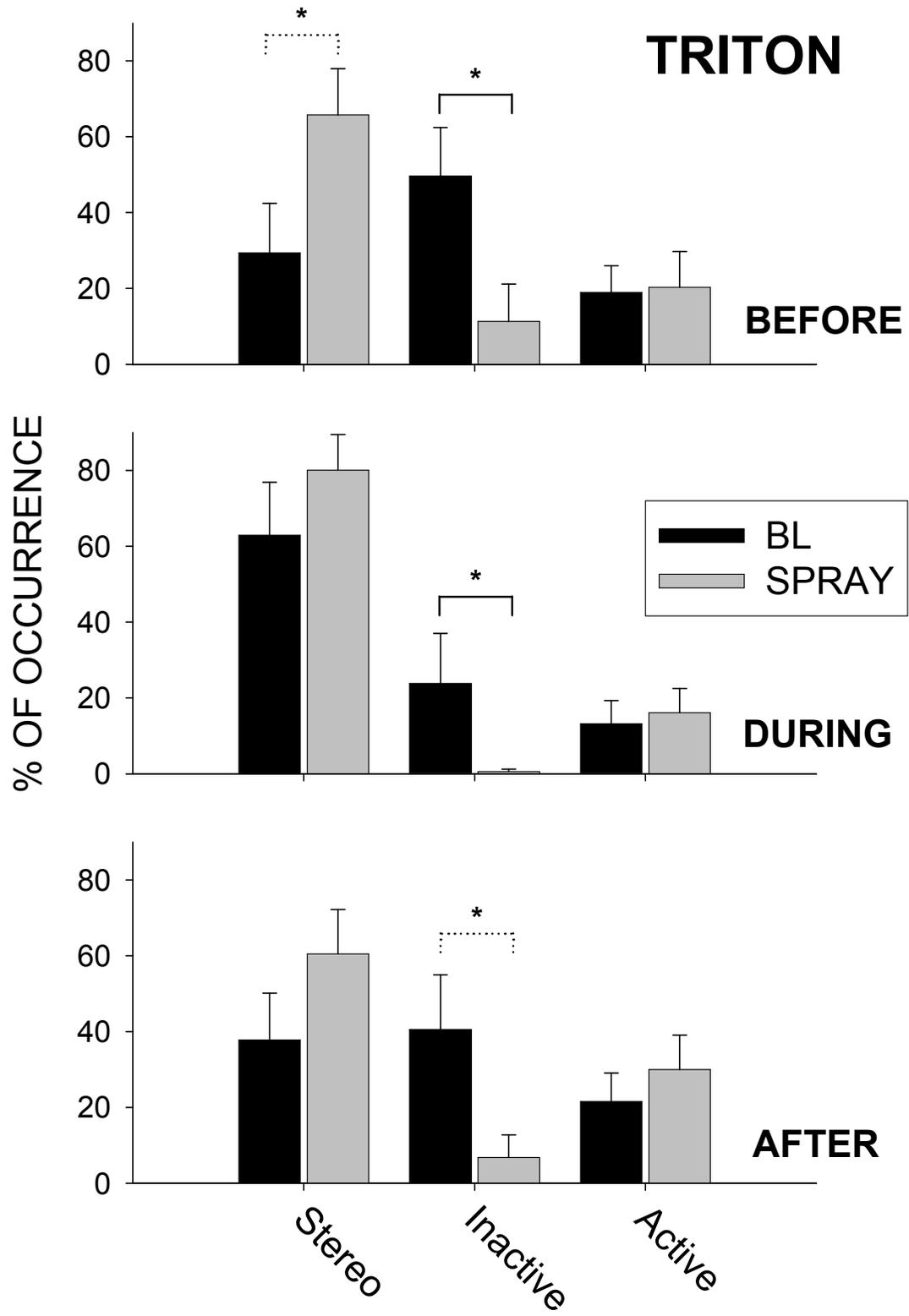
**TRITON ALONE
VS.
WITH TUNDRA**
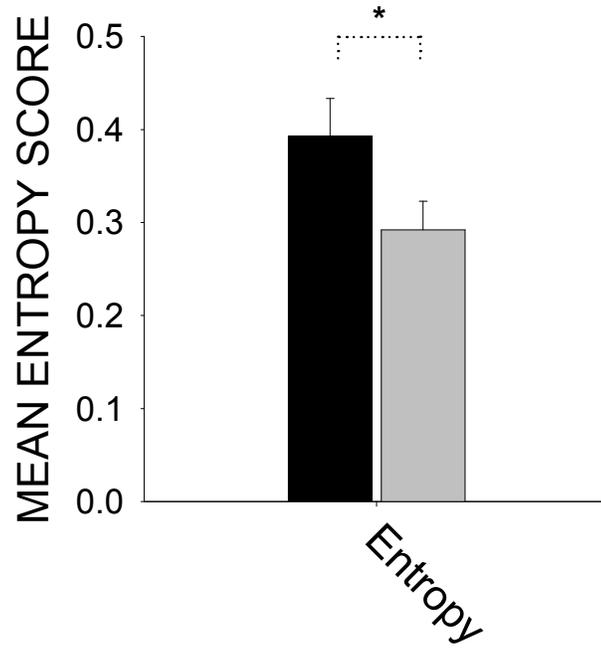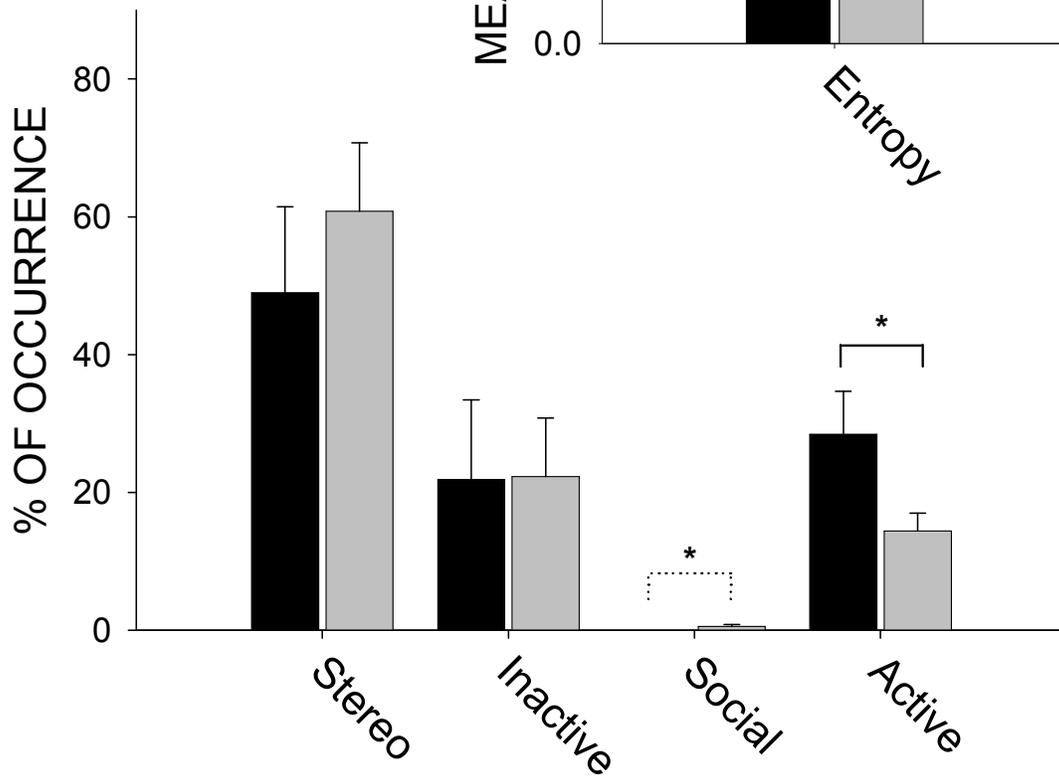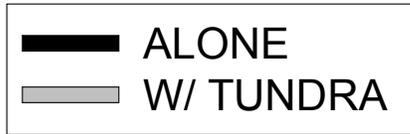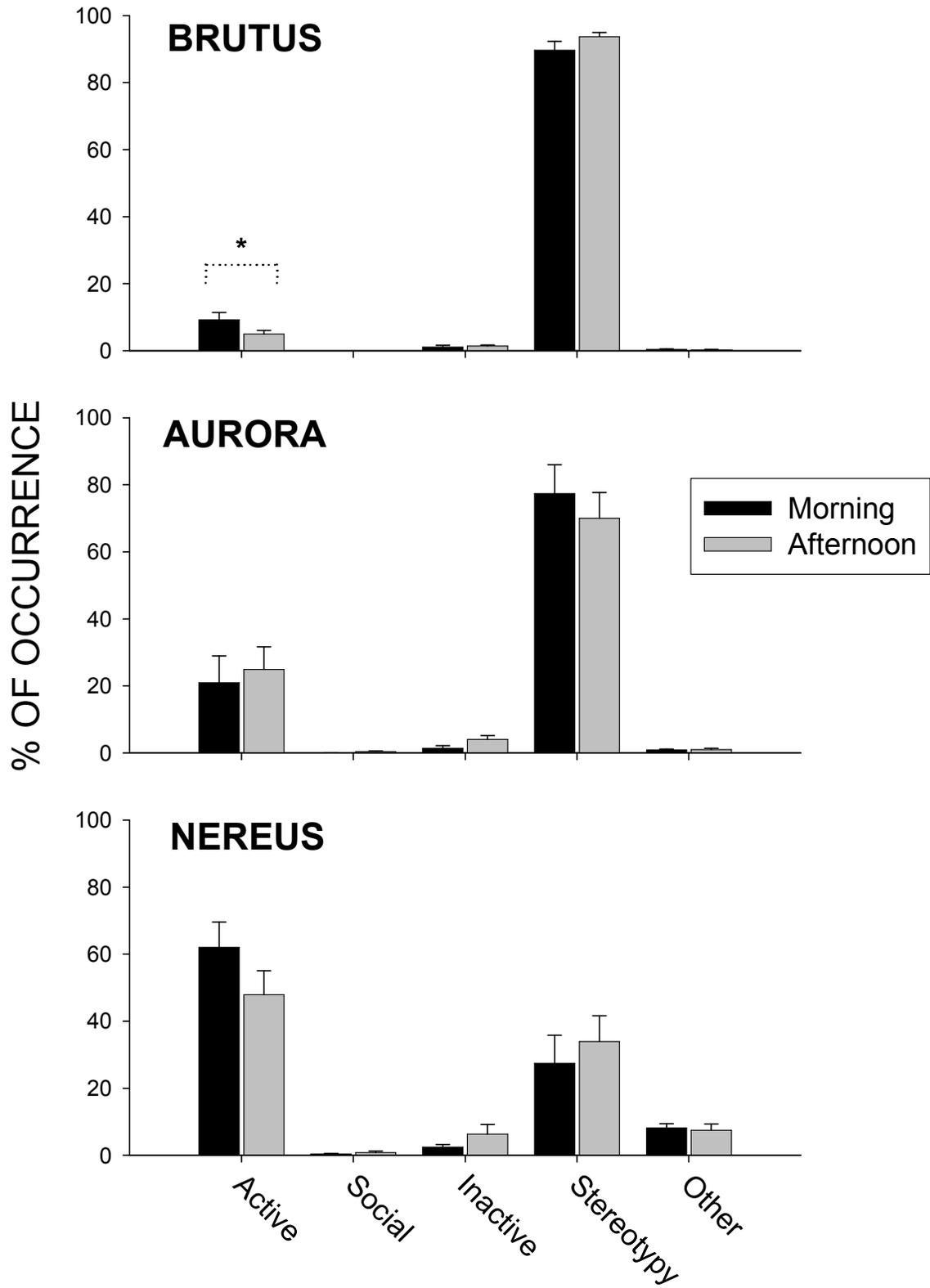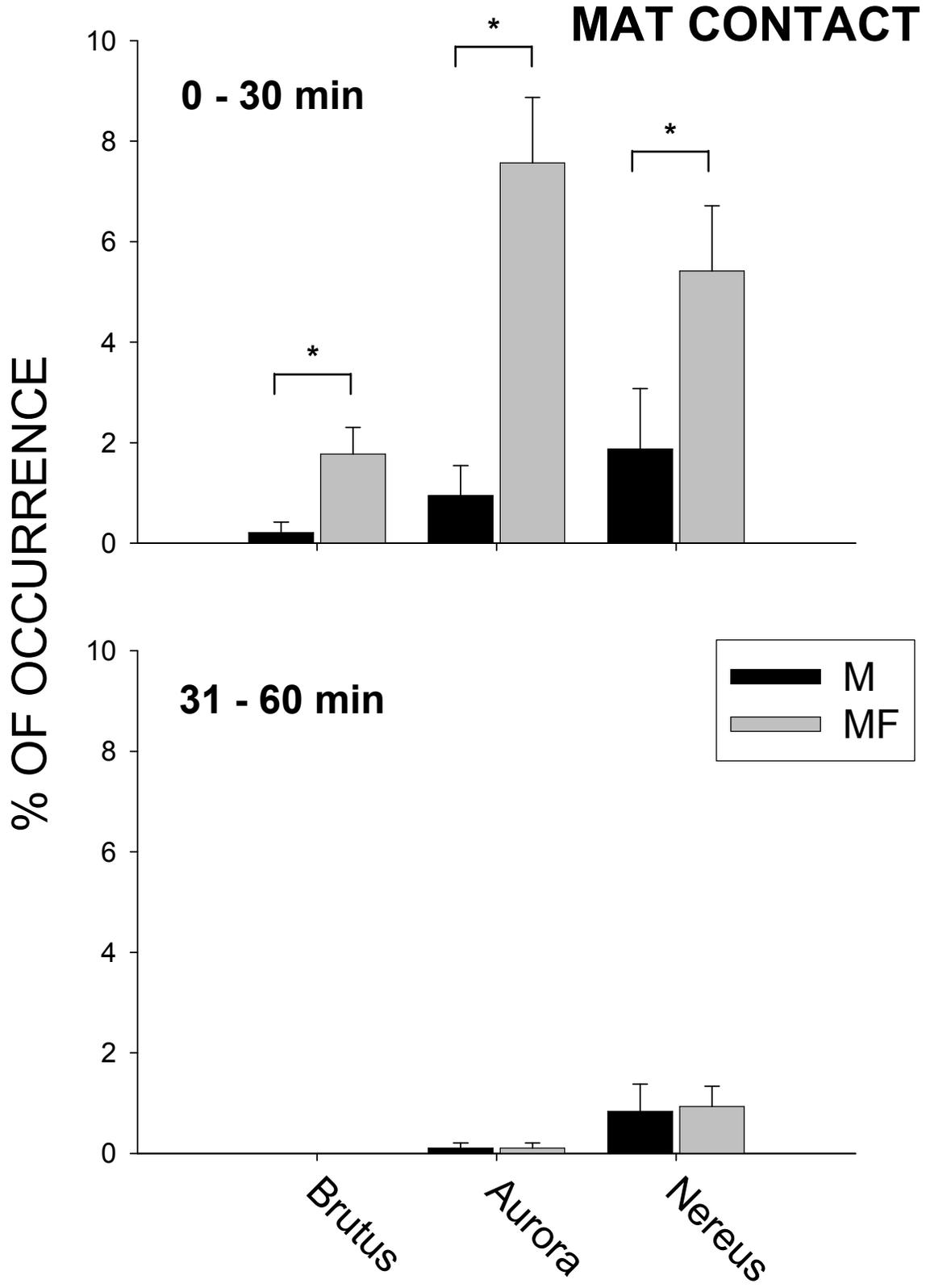
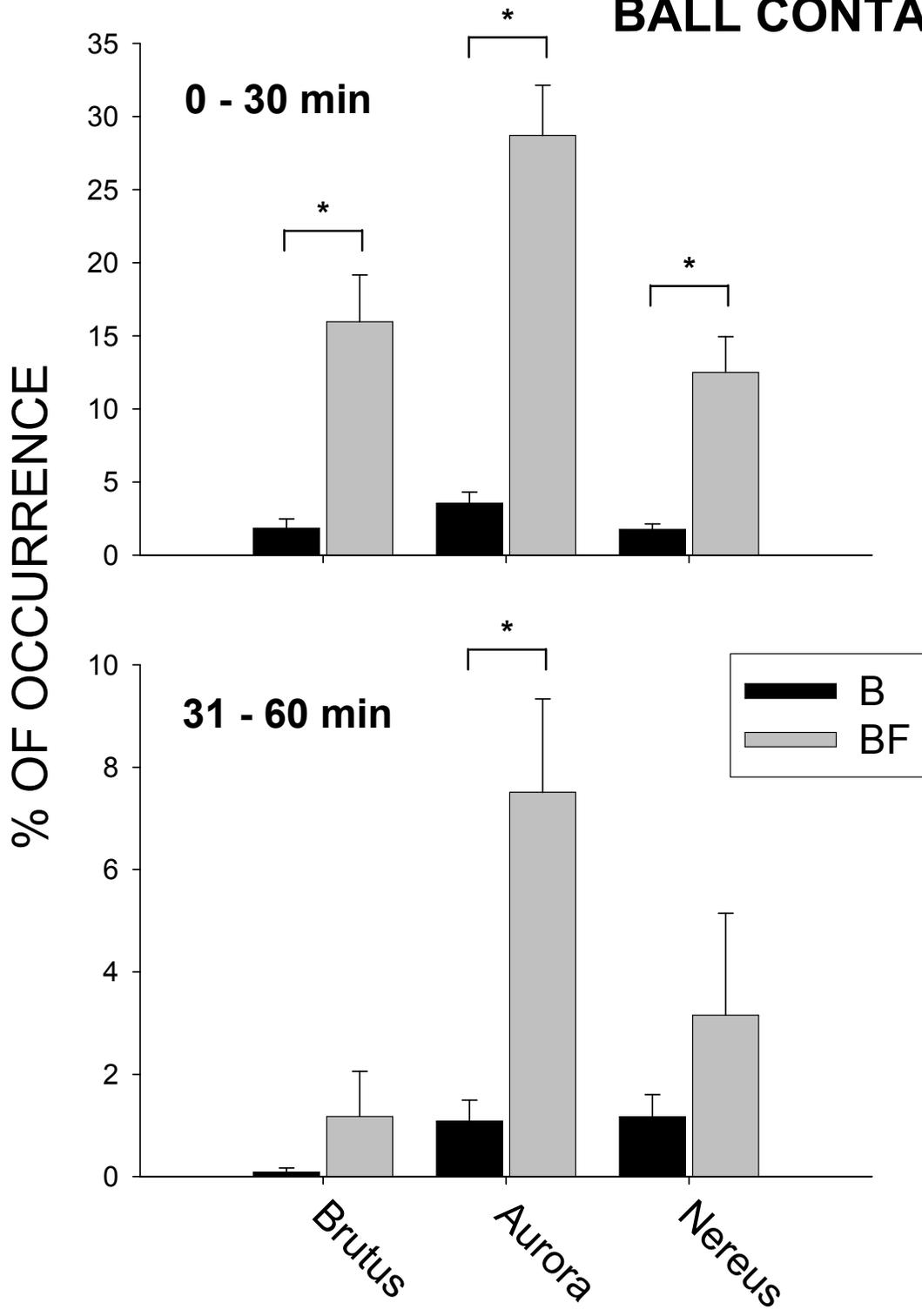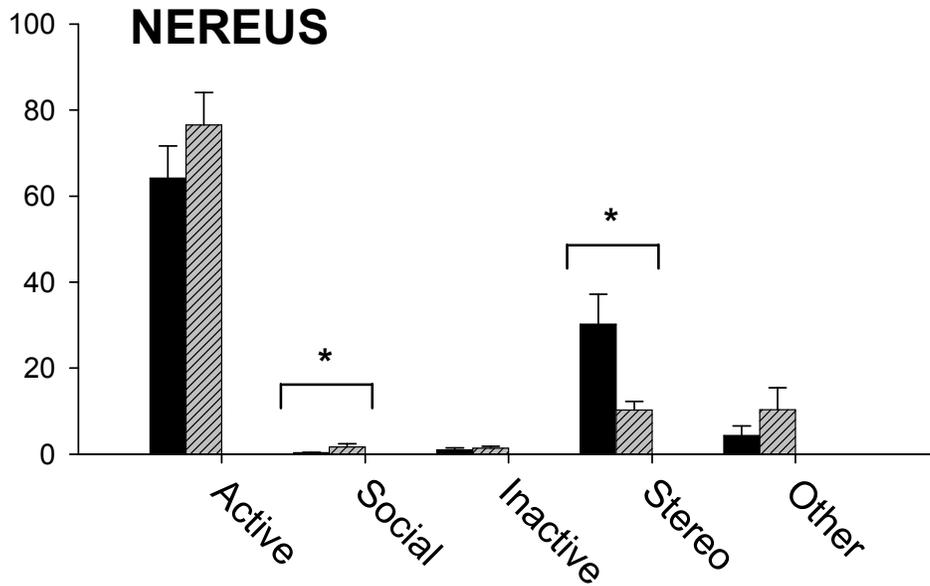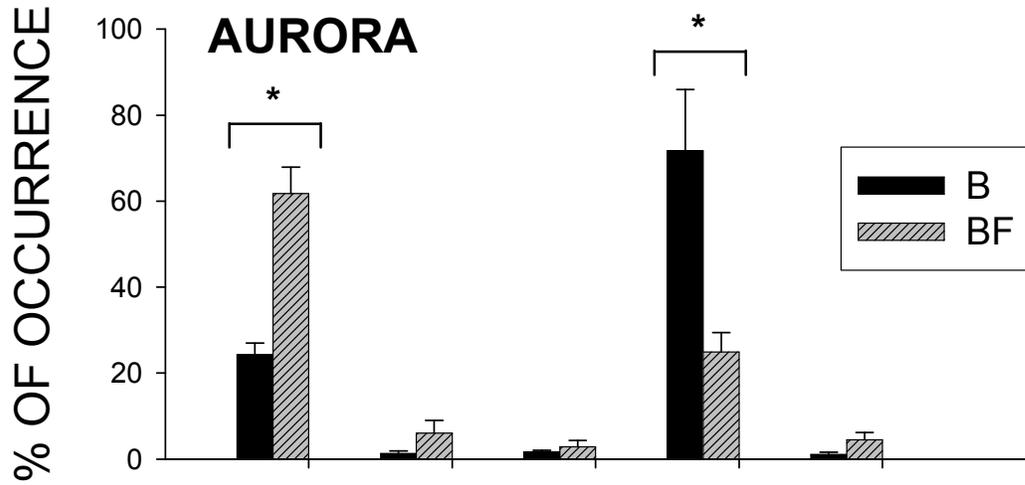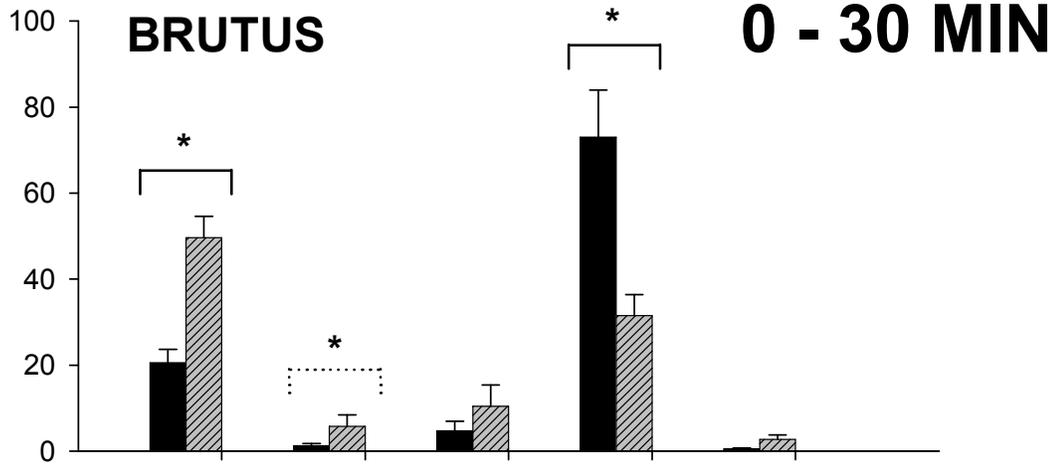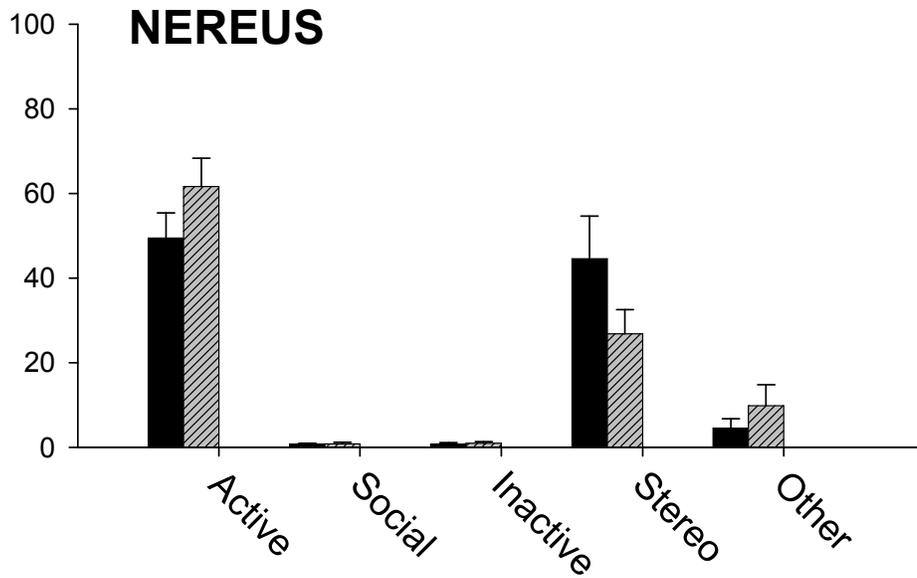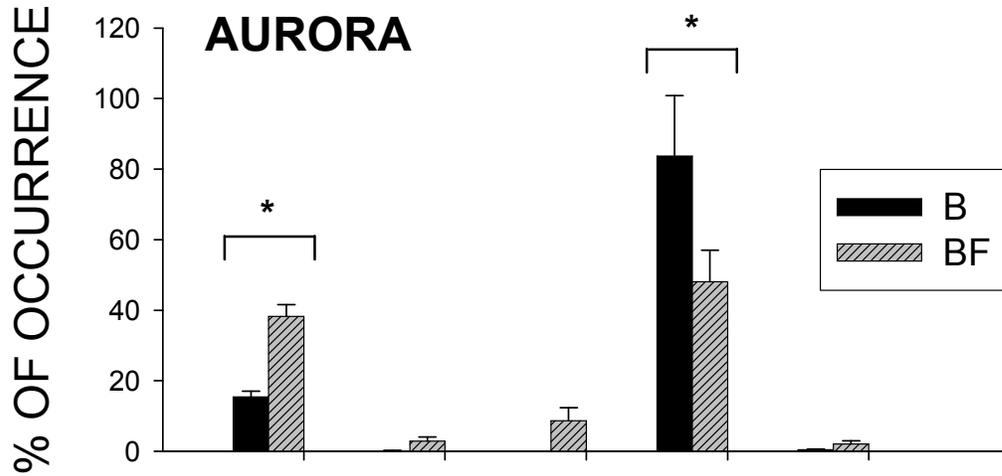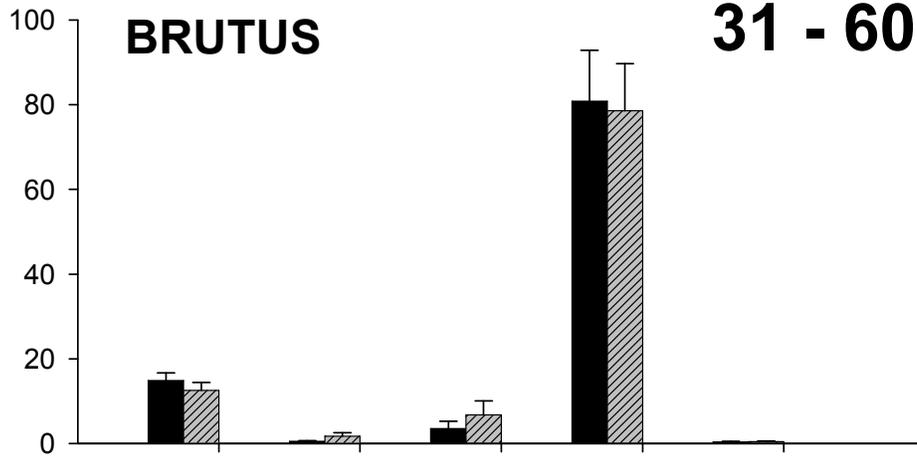BALL CONTACT
(PER BF SESSION)

EDUARDO J. FERNANDEZ

http://mypage.iu.edu/~eduferna/
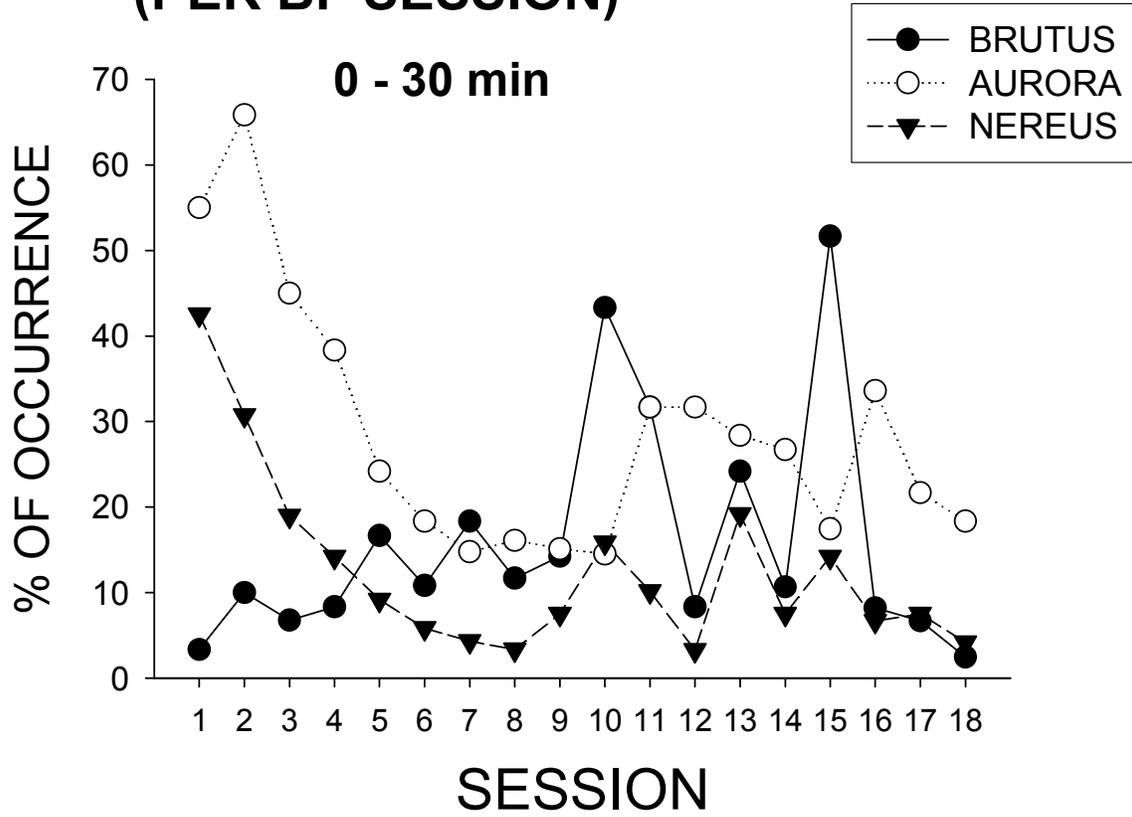
Doctoral Candidate – Indiana University
Psychological and Brain Sciences Department
Advisor: William Timberlake, Ph.D.

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EDUCATION

2009 (May)	Ph.D. – Psychology, Indiana University Minors: Animal Behavior and Neuroscience G.P.A. 3.9
2003	M. S. – Behavior Analysis, University of North Texas, Denton, TX G.P.A. 4.0
1997	B. S. – Psychology, University of Florida, Gainesville, FL G.P.A. 3.54 overall; 3.86 Psychology
1997	B. A. – Sociology, University of Florida, Gainesville, FL

HONORS

2006	Bill Rowland Student Mentoring Award, Indiana University
2005	Marian Breland-Bailey Student Presenter Award, ABA
2003	Outstanding Graduate Student, University of North Texas
2001-2002	Who's Who in Graduate Students, University of North Texas
1997	Golden Key, National Honor Society
1995-1996	Dean's List
1993	Phi Theta Kappa
1992-1993	Dean's List
1992-1993	The National Dean's List

GRANTS AND FELLOWSHIPS

2009-2010	NSF Minority Postdoctoral Fellowship, $120,000
2007, 2005-2006, 2002-2003	Center for the Integrative Study of Animal Behavior Graduate Fellowship
2003	Summer Research Grant, Indiana University, $4000
1992-1993	Broward Community College Scholarship

PROFESSIONAL EXPERIENCE

2004-2007	Board Member, Animal Behavior Management Alliance
2004-2006	Chair, Animal Trainer's Forum Special Interest Group, Association for Behavior Analysis

2000-2004	Program Chair, Animal Trainer's Forum Special Interest Group, Association for Behavior Analysis
1999-present	Moderator, Animal Reinforcement Forum http://listserv.indiana.edu/archives/arf-l.html
1999-2002	President, Organization for Reinforcement Contingencies with Animals, University of North Texas
2001	Quiz System Moderator/Programmer, Behavior Principles I & II, University of North Texas
2001	Therapist, In-home Behavior Analytic Autism Therapy, Dallas, TX
2001	Trainer, Falconry Training, Dallas, TX
2000	Therapist, Dallas-Ft. Worth Center for Autism, University of North Texas
2000	Head Behavioral Coordinator, Seascape 2000, Bequia, West Indies
2000	Pet Trainer/Researcher, Denton Humane Society, Denton, TX
1996	Volunteer, Alachua Halfway House, Gainesville, FL

PROFESSIONAL ASSOCIATIONS

2003-present	American Zoos and Aquariums Association
2001-present	Animal Behavior Management Alliance
1997-present	Association for Behavior Analysis
1999-2003	Texas Association for Behavior Analysis

RESEARCH EXPERIENCE

2009-present	Examinations of Stereotypy Development in Primates, University of Washington and the Washington National Primate Center Advisor: Jim Ha
2007-2008	The "Seal-sicle": An Empirical Examination of a Feeding Enrichment Device with Polar Bears, Indiana University and the Indianapolis Zoo Advisor: William Timberlake
2006-2007	24-hour Activity Budgets of Rats in a Zoo-Like Laboratory Setting, Indiana University Advisor: William Timberlake
2005-2007	The Effects of Foraging Devices as Enrichment in Captive Walruses, Indiana University and the Indianapolis Zoo Advisor: William Timberlake
2002-2006	Fixed- and Variable-Time Schedules and Stereotypic Activity in Adult Captive Polar Bears, Indiana University and the Indianapolis Zoo Advisor: William Timberlake
2005	An Examination of a Live Feed Enrichment Device on Swimming Activity in Two Species of Penguins, Indiana University and the Cincinnati Zoo Advisor: William Timberlake
2004	Testing Enrichment Devices Selected by Preference Assessments with Two Species of Lemur, Indiana University and the Indianapolis Zoo Advisor: William Timberlake

2003-2004	Paired-choice Food Preference Assessments Used to Determine Enrichment Items across Four Species of Lemur, Indiana University and the Indianapolis Zoo Advisor: William Timberlake
2003-2004	Superstition Re-Revisited: An Examination of Niche-Related Mechanisms during Fixed-Time Food Schedules in Laboratory Pigeons, Indiana University Advisor: William Timberlake.
2003	Training Penguins to Interact with Enrichment Devices for Lasting Effects, Indiana University and the Cincinnati Zoo Advisor: William Timberlake.
2003	An Examination of Foraging-Related Behaviors in Two Female Walruses, Indiana University and the Indianapolis Zoo Advisor: William Timberlake
2002	Preference-Assessments with Cotton-Top Tamarins, University of North Texas and the Frank Buck Zoo Advisor: Jesus Rosales-Ruiz
2001-2002	Successive/Simultaneous Color Discriminations with Goats, University of North Texas and the Frank Buck Zoo Advisor: Jesus Rosales-Ruiz
2001-2002	An Examination of Target Training/Shaping with a Ring-Tailed Lemur and African Crested Porcupine, University of North Texas and Animal Edutainment Advisor: Jesus Rosales-Ruiz
2001-2002	An Examination of Target Training in a Female Ostrich, University of North Texas and the Frank Buck Zoo Advisor: Jesus Rosales-Ruiz
2001-2002	An Examination of Halter Leading/Shaping with Goats, University of North Texas and the Frank Buck Zoo Advisor: Jesus Rosales-Ruiz
2000-2001	Reducing Escape Behaviors in Two Species of Sheep, University of North Texas and the Frank Buck Zoo Advisor: Jesus Rosales-Ruiz
2000	The Effects of a Large Scratching Post to Reduce Tiger Enclosure Destruction, University of North Texas and Bridgeport Nature Center Advisor: Jesus Rosales-Ruiz.
2000	The Effects of a Delayed Cue Procedure with a Horse, University of North Texas Advisor: Jesus Rosales-Ruiz.
2000	Research Assistant, University of North Texas and Denton State School Supervisor: Richard Smith
1996	Student, Laboratory Procedures in Behavior Analysis, University of Florida Professor: Timothy Hackenberg

1996	Research Assistant, University of Florida and Shands Diabetes Pediatric Clinic Supervisor: Gary Geffken

TEACHING EXPERIENCE

2008	Assistant Instructor, K300 – Statistics Supervisor: Michael Jones
2007	Teaching Assistant, P101 - Introduction to Psychology Supervisor: Ben Sklar
2006	Instructor, P325 – The Psychology of Learning
2005	Instructor, P211 – Experimental Methods in Psychology - Lab
2004	Teaching Assistant, P106 – General Psychology – Honors Supervisor: Susan Jones
2004	Teaching Assistant, P327 – The Psychology of Motivation Supervisor: Preston Garraghty
2004	Teaching Assistant, P211 – Methods of Experimental Psychology Supervisor: Brian Bowdle
2004	Teaching Assistant, P457 – Forensic Psychology Supervisor: Michael Jenuwine
2003	Teaching Assistant, P325 – Psychology of Learning Supervisor: Marie Cassar
2003	Teaching Assistant, P417 – Animal Behavior Supervisor: William Timberlake
2001-2002	Teaching Fellow, BEHV 2300 – Behavior Principles I Supervisor: Sigrid Glenn
2000	Teaching Fellow, BEHV 3150 – Basic Behavior Principles Supervisor: Sigrid Glenn
2000	Teaching Assistant, BEHV 4900 – Applied Behavior Analysis Supervisor: Joel Greenspoon
1999-2000	Teaching Assistant, BEHV 3150 – Basic Behavior Principles Supervisor: Sigrid Glenn
1996-1997	Manager, EAB 4724 – Precise Behavior Management Supervisor: Henry Pennypacker

PAPERS PRESENTED

May, 2009	Fernandez, E.J., & Timberlake, W. Towards a Functional, Foraging-Based Model of Stereotypic Activity in Captive Animals. Paper presented at the Association for Behavior Analysis conference, Phoenix, AZ.
July, 2008	Fernandez, E.J. Guest Speaker, Behaviorists at the Zoo: Using Training and Enrichment Data with Reptiles. Paper presented at the Reptile Training Workshop, Orlando, FL.

May, 2008	Fernandez, E. J., & Timberlake, W. Foraging and Walruses: An Examination of Functional Enrichment at the Indianapolis Zoo. Paper presented at the Association for Behavior Analysis Conference, Chicago, IL.
Mar, 2008	Smith, A., Hirschauer, M., Fernandez, E. J., & Timberlake, W. The "Seal-Sicle": An Examination of a Prey-Like Foraging Device on Stereotypic and General Activity in Captive Polar Bears (Ursus maritimus). Paper presented at the Tri-State Conference on Animal Learning and Behavior, Lexington, KY.
Nov, 2007	Fernandez, E. J., & Timberlake, W. The Effects of Foraging Devices as Enrichment in Captive Walruses (Odobenus rosmarus). Paper presented at the International Marine Animal Trainers' Conference, Indianapolis, IN.
Nov, 2007	Fernandez, E. J., & Timberlake, W. The "Seal-Sicle": An Examination of a Prey-Like Foraging Device on Stereotypic and General Activity in Captive Polar Bears (Ursus maritimus). Paper presented at the International Marine Animal Trainers' Conference, Indianapolis, IN.
June, 2007	Fernandez, E. J. From Penguins to Polar Bears: The Implications of Animal Welfare. Paper presented at the Bloomington Science Café, Bloomington, IN.
April, 2007	Finn, S., Smith, A., Fernandez, E. J., & Timberlake, W. An Examination of a Mobile Feeding Device with Captive Walruses (Odobenus rosmarus). Paper presented at the Tri-State Conference on Animal Learning and Behavior, West Lafayette, IN.
April, 2007	Brass, M., Fernandez, E. J., & Timberlake, W. The "Seal-Sicle": An Examination of a Prey-Like Foraging Device in Captive Polar Bears (Ursus maritimus). Paper presented at the Tri-State Conference on Animal Learning and Behavior, West Lafayette, IN.
April, 2007	Fernandez, E. J., & Timberlake, W. Twelve-Hour Activity Budgets and Foraging Behavior in the Laboratory Rat. Paper presented at the Tri-State Conference on Animal Learning and Behavior, West Lafayette, IN.
Jan, 2007	Fernandez, E. J., & Timberlake, W. The Effects of Foraging Devices as Enrichment in Captive Walruses (Odobenus rosmarus). Paper presented at the Animal Behavior Management Alliance, Miami, FL.
May, 2006	Fernandez, E. J., & Timberlake, W. The Effects of Foraging Devices as Enrichment in Captive Walruses (Odobenus rosmarus). Paper presented at the Association for Behavior Analysis Conference, Atlanta, GA.
May, 2006	Fernandez, E. J., & Timberlake, W. Superstition Re-revisited: An Examination of Niche-Related Mechanisms Underlying Schedule Produced Behavior in Pigeons. Paper presented at the Association for Behavior Analysis Conference, Atlanta, GA.
April, 2006	Frommey, S., Fernandez, E. J., & Timberlake, W. The Effects of Foraging Devices as Enrichment in Captive Walruses Paper presented at the Tri-State Conference on Animal Learning and Behavior, Indianapolis, IN.
April, 2006	Fernandez, E. J., & Timberlake, W. Training Penguins to Interact with Enrichment Items for Lasting Effects. Paper presented at the Tri-State Conference on Animal Learning and Behavior, Indianapolis, IN.

April, 2006   Pickens, S., Fernandez, E. J., & Timberlake, W. Selecting and Testing Environmental Enrichment in Several Species of Lemur. Paper presented at the Tri-State Conference on Animal Learning and Behavior, Indianapolis, IN.

April, 2006   Tamborski, M., Fernandez, E. J., & Timberlake, W. Polar bear stereotypic and general activity under fixed- and variable-time schedules. Paper presented at the Tri-State Conference on Animal Learning and Behavior, Indianapolis, IN.

April, 2006   Fernandez, E. J., & Timberlake, W. The Effects of Foraging Devices as Enrichment in Captive Walruses (Odobenus rosmarus). Paper presented at the Indiana University Animal Behavior Conference, Bloomington, IN.

May, 2005   Fernandez, E. J., & Timberlake, W. The Functional Value of Enrichment: Determining Environmental Enrichment Effects in Lemurs through the Use of Paired-Choice Preference Assessments. Paper presented at the Association for Behavior Analysis Conference, Chicago, IL.

April, 2005   Fernandez, E. J., & Timberlake, W. The Functional Value of Enrichment: Determining Environmental Enrichment Effects in Lemurs through the Use of Paired-Choice Preference Assessments. Paper presented at the Animal Behavior Management Alliance Conference, Houston, TX.

April, 2005   Fernandez, E. J., & Timberlake, W. The Functional Value of Enrichment: Determining Environmental Enrichment Effects in Lemurs through the Use of Paired-Choice Preference Assessments. Paper presented at the Indiana University Animal Behavior Conference, Bloomington, IN.

March, 2005   Fernandez, E. J., Kinley, R., and Timberlake, W. Training Penguins to Interact with Enrichment Items for Lasting Effects. Paper presented at the American Zoos and Aquarium's Avian Scientific Advisory Group Penguin Workshop, Kansas City, MO.

May, 2004   Fernandez, E. J., Chair, Research Methodology in the Management of Dog Behavior. Symposium presented at the Association for Behavior Analysis Conference, Boston, MA.

May, 2004   Fernandez, E. J., and Timberlake, W. Training Penguins to Interact with Enrichment Items for Lasting Effects. Paper presented at the Association for Behavior Analysis Conference, Boston, MA.

May, 2004   Fernandez, E. J., and Timberlake, W. Fixed-Time Food Schedules and their Effects on Activity Patterns in Two Adult Polar Bears (Ursus maritimus). Paper presented at the Association for Behavior Analysis Conference, Boston, MA.

April, 2004   Fernandez, E. J., and Timberlake, W. Superstition Re-Revisited: An Examination of Niche-Related Mechanisms Underlying Schedule Produced Behavior in Pigeons. Paper presented at the Indiana University Animal Behavior Conference, Bloomington, IN.

April, 2004   Fernandez, E. J., Kinley, R., and Timberlake, W. Training Penguins to Interact with Enrichment Items for Lasting Effects. Paper presented at the Animal Behavior Management Alliance, Baltimore, MD.

April, 2004   Fernandez, E. J., and Timberlake, W. Fixed-Time Food Schedules and their Effects on Activity Patterns in Two Adult Polar Bears (Ursus maritimus). Paper presented at the Animal Behavior Management Alliance, Baltimore, MD.

May, 2003   Fernandez, E. J., Chair, Behavior Research and Applications in Zoo Settings. Symposium presented at the Association for Behavior Analysis Conference, San Francisco, CA.

May, 2003   Fernandez, E. J. The Animal Reinforcement Forum (ARF): When Animal Trainers and Behavior Analysts Meet. Paper presented at the Association for Behavior Analysis Conference, San Francisco, CA.

May, 2003   Fernandez, E. J., and Timberlake, W. The Effects of Fixed- and Variable-Time Schedules on Stereotypic Behaviors in an Adult Polar Bear. Paper presented at the Association For Behavior Analysis Conference, San Francisco, CA.

May, 2002   Fernandez, E. J. Behavior Principles and Their Use in Animal Training in Applied Systems. Paper presented at the Association for Behavior Analysis Conference, Toronto, ON (Canada).

May, 2002   Fernandez, E. J., Dorey, N., & Rosales-Ruiz, J. Shifting and Stationing with Monkeys. Paper presented at the Association for Behavior Analysis Conference, Toronto, ON (Canada).

May, 2002   Dorey, N, Fernandez, E.J., & Rosales-Ruiz, J. (May, 2002). Target Training in Ostriches. Paper presented at the Association for Behavior Analysis Conference, Toronto, ON (Canada).

Feb, 2002   Fernandez, E. J., Dorey, N., & Rosales-Ruiz, J. ORCA: A New Kind of Lab. Paper presented at the Animal Behavior Management Alliance Conference, San Diego, CA.

May, 2001   Fernandez, E. J., Chair, Data and Animal Training: Crossing that Bridge… Symposium presented at the Association for Behavior Analysis Conference, New Orleans, LA.

May, 2001   Fernandez, E. J. ORCA: Zoos, Tigers, Horses, and the Occasional Impaired Dog. Paper presented at the Association for Behavior Analysis Conference, New Orleans, LA.

POSTERS PRESENTED

Nov, 2006   Fredebaugh, S. L., Fernandez, E. J., & Timberlake, W. Possible Influences of Positive Scent Stimuli on the Behavior of Captive Polar Bears (Ursus maritimus). Poster presented at the Sigma Xi Student Research Conference, Detroit, MI.

Nov, 2005   Pickens, S. R., Parmer, M. A., Tamborski, J. A., Fernandez, E. J., & Timberlake, W. The Effects of Foraging Devices as Enrichment in Captive Walruses (Odobenus rosmarus). Poster presented at the Indiana University Undergraduate Research Conference, Indianapolis, IN.

Nov, 2003   Rogerson, K., Walsh, K., Fernandez, E. J., and Timberlake, W. Fixed-Time Food Schedules and their Effects on Activity Patterns in Two Adult Polar Bears (Ursus maritimus). Poster Presented at the Indiana University Undergraduate Research Conference, Indianapolis, IN.

Aug, 2003   Fernandez, E. J., and Timberlake, W. Fixed Time Food Schedules and Their Effect on General Activity Patterns in Two Adult Polar Bears. Poster Presented at the American Zoos and Aquariums Conference, Columbus, OH.

Feb, 2002   Fernandez, E. J., and Rosales-Ruiz, J. Training Appropriate Petting Zoo Behaviors in La Mancha Goats. Poster presented at the Animal Behavior Management Alliance Conference, San Diego, CA.

Feb, 2002   Fernandez, E. J., and Rosales-Ruiz, J. Training Petting Zoo Sheep to Act Like Petting Zoo Sheep. Poster presented at the Animal Behavior Management Alliance Conference, San Diego, CA.

Feb, 2002   Dorey, N., Fernandez, E. J., and Rosales-Ruiz, J. Target Training in Ostriches. Poster presented at the Animal Behavior Management Alliance Conference, San Diego, CA.

May, 2001   Fernandez, E. J., Scarbro, J., Harris, B., and Rosales-Ruiz, J. Training Petting Zoo Sheep to Act Like Petting Zoo Sheep. Poster presented at the Association for Behavior Analysis Conference, New Orleans, LA.

May, 2001   Fernandez, E. J., Cermak, J., Haycraft, C., and Rosales-Ruiz, J. Successively Simultaneous? Stimulus Control Issues for a Target Trained Goat. Poster presented at the Association for Behavior Analysis Conference, New Orleans, LA.

May, 2001   Murphy, P., Fernandez, E. J., Scarbro, J., Schinman, D. M., and Rosales-Ruiz, J. Training Appropriate Petting Zoo Behaviors in 3 La Mancha Goats. Poster presented at the Association for Behavior Analysis Conference, New Orleans, LA.

May, 2001   Murphy, P., Fernandez, E. J., and Rosales-Ruiz, J. Transfer of Stimulus Control from a Visual to an Auditory Cue in a Horse. Poster presented at the Association for Behavior Analysis Conference, New Orleans, LA.

March, 2001   Fernandez, E. J., Harris, B., and Rosales-Ruiz, J. Training to Enrichment Items: A Shift of Scratching Behavior. Poster presented at the Texas Association for Behavior Analysis Conference, Houston, TX.

March, 2001   Fernandez, E. J., Scarbro, J., Harris, B., and Rosales-Ruiz, J. Training Petting Zoo Sheep to Act Like Petting Zoo Sheep. Poster presented at the Texas Association for Behavior Analysis Conference, Houston, TX.

March, 2001   Fernandez, E. J., Scarbro, J., Schinman, D. M., Topolovic, P., Murphy, P., and Rosales-Ruiz, J. Training Appropriate Petting Zoo Behaviors in 3 La Mancha Goats. Poster presented at the Texas Association for Behavior Analysis Conference, Houston, TX.

March, 2001   Murphy, P., Fernandez, E. J., and Rosales-Ruiz, J. Transfer of Stimulus Control from a Visual Cue to an Auditory Cue in a Horse. Poster presented at the Texas Association for Behavior Analysis Conference, Houston, TX.

March, 2000 Fernandez, E. J. ORCA: An Introduction to Animal Training at the University of North Texas. Poster presented at the Texas Association for Behavior Analysis Conference, Dallas, TX.

PEER-REVIEWED PUBLICATIONS

1. Fernandez, E.J., Tamborski, M.A., Pickens, S.R., & Timberlake, W. (in press). Visitor Interactions in Zoos: What are They and How do They Affect Entertainment and Welfare in the Modern Zoo? Applied Animal Behaviour Science.

2. Fernandez, E.J., & Timberlake, W. (2009). Selecting and testing environmental enrichment in lemurs. Manuscript submitted for publication.

3. Fernandez, E.J., & Timberlake, W. (2009). The effects of foraging devices as enrichment in captive walruses (Odobenus rosmarus). Manuscript in progress.

4. Fernandez, E.J., & Timberlake, W. (2009). Foraging and stereotypic activity in captive adult polar bears (*Ursus maritimus*). Manuscript in progress.

5. Fernandez, E.J., Kinley, R., & Timberlake, W. (2009). Training penguins to interact with enrichment items for lasting effects. Manuscript in progress.

6. Fernandez, E.J., & Timberlake, W. (2008). Mutual benefits of animal research collaborations between zoos and academic institutions. Zoo Biology.

7. Yin, S., Fernandez, E.J., Pagan, S., Richardson, S.L., & Snyder, G. (2008). Efficacy of a remote-controlled, positive-reinforcement, dog-training system for modifying problem behaviors exhibited when people arrive at the door. Applied Animal Behaviour Science.

8. Fernandez, E.J., Dorey, N.R., & Rosales-Ruiz, J. (2004). A two-choice preference assessment with five cotton-top tamarins (Saguinus oedipus). Journal of Applied Animal Welfare Science, 7, 163-169.

SELECT OTHER PUBLICATIONS (8 Total)

2001 Fernandez, E. J. ORCA: A New Kind of Lab. The Clicker Journal: The Magazine for Animal Trainers, 51, 18-23.

2001 Fernandez, E. J. Negative Reinforcement's Evil Twin, Punishment. Cross Keys Books' E-Zine. http://www.crosskeysbooks.com.

2001 Fernandez, E. J. Click or Treat: A Trick or Two in the Zoo. American Animal Trainer Magazine, 2(2), 41-44.

2000 Fernandez, E. J. (2000). An Introduction to ORCA. American Animal Trainer Magazine, 1(4), 38-40.

REFERENCES

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